Field Manual for Applying Rapid Ecological Integrity Assessments in Upland Plant Communities of Washington State (DRAFT)

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Photograph of Judy's Tamarack Park, Naneum Ridge, near Ellensburg, WA. Photograph by: Tynan Ramm-Granberg

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ACKNOWLEDGEMENTS

This document builds upon the upland Ecological Integrity Assessments (EIAs) for Ecological Systems developed by Crawford (2011a-aj; Crawford & Rocchio, 2011; Rocchio, 2011a-e). In addition, many of the methods and metrics presented here are adaptations of those originally developed for wetlands in Faber-Langendoen et al. (2016a, 2016b, 2016c) and Rocchio et al. (2016). Nordman et al. (2016) and Foti (2016) provided additional context for upland applications of EIA.

1.0 INTRODUCTION

Ecological Integrity Assessments (EIA) summarize the condition/integrity of individual occurrences of ecosystems through consideration of composition, structure, and ecological processes. The method can be applied to occurrences as small as 0.05 ha and as large as thousands of hectares. EIAs can be conducted at three different sampling intensities: Level 1 (entirely GIS-based), Level 2 (rapid, mostly qualitative, field-based), and Level 3 (intensive, quantitative, field-based).

This document describes the protocols for applying rapid, field-based Ecological Integrity Assessments (Level 2 EIA) to upland ecosystems in Washington State. For wetland ecosystems, reference Rocchio et al. (2016). Additional overviews of ecological integrity assessments are found in Rocchio & Crawford (2011), Faber-Langendoen et al. (2016a,b,c).

In 2011, the Washington Natural Heritage Program (WNHP) developed EIA scorecards for 67 of the 99 Ecological Systems which occur in Washington State (Crawford, 2011a-aj; Crawford & Rocchio, 2011; Rocchio, 2011a-e). This publication is the result of efforts to simplify those Ecological System-specific EIA scorecards into one document. After years of employing the system-specific scorecards, it became obvious there were more similarities across systems than differences. This effort also matches a similar approach taken for wetland and riparian EIAs (Faber-Langendoen et al., 2016b,c; Rocchio et al., 2016).

While the rapid nature of Level 2 assessments necessitates primarily qualitative metrics, the procedures delineated here provide a repeatable structure that will aid in evaluation of baseline ecological integrity of occurrences, as well as repeat-monitoring to establish trends. The EIA assessment target is defined by classification criteria. For upland ecosystems, we use "Ecological Systems of Washington State: A Guide to Identification" (Rocchio & Crawford, 2015). Specific project objectives may result in further adjustments to the assessment target. The process for establishing assessment target boundaries (i.e., the assessment area) and protocols for collecting data necessary to apply the EIA metrics are provided in this document. Section 2 focuses on the steps needed to employ the Level 2 EIA, including which metrics to apply based on ecosystem type. Section 3 provides protocols for measuring each metric.

Once metrics are scored, they are rolled up into five Major Ecological Factors: Landscape, Edge, Vegetation, Soils, and Size. These Major Ecological Factor scores are in turn rolled up into three Primary Rank Factors: Landscape Context, Condition, and size. These three factors are then combined to calculate an overall EIA score/rank.

Initial drafts of this protocol contained a sixth Major Ecological Factor, "Natural Disturbance Regime", which was intended to assess the degree to which natural disturbances were functioning within their natural range of variability at an ecosystem occurrence. However, in a rapid, level 2 EIA assessment, the observer does not have the luxury of witnessing disturbance events and must rely on proxy indicators—indicators that are already assessed in other metrics, such as VEG3 Native Plant Species Composition, VEG4 Vegetation Structure, VEG5 Woody Regeneration, and VEG6 Coarse Woody Debris, Snags, and Litter. For example, an occurrence of a Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Ecological System may exhibit departure from its historic fire regime (frequent, low-intensity fires) via abundant tree regeneration by relatively fire-intolerant species such as *Pseudotsuga menziesii*. That indicator of altered disturbance regime is already measured in the VEG5 Woody Regeneration metric. Further testing may prove natural disturbance regime to be a useful metric for level 3 EIAs, in which more in-depth investigations of the disturbance history itself can take place (e.g. via reconstructed fire histories).

Primary and major ecological factor scores/ranks can be helpful for understanding the current status of primary ecological drivers. Whether one needs to roll up scores is dependent on the project objective. Land managers may only be interested in individual metric scores, as these provide insight into specific management needs, goals, and measures of success (e.g. a low score in the Invasive Nonnative Plant Cover metric (VEG2) may indicate the need for an herbicide treatment). On the other hand, if the goal is to compare or prioritize sites for conservation, restoration, or management actions, an overall EIA score/rank may be needed. For example, a land trust considering the purchase of one of three potential properties may want to focus on the site that has the most-intact ecological integrity.

1.1 Glossary of Frequently Used Terms

- Occurrence: An area of land where an ecosystem type is, or was, present. This can be a single patch/stand of a natural community, or a cluster of patches/stands within a given distance of one another that are considered as a single occurrence on the basis of shared ecological characteristics (NatureServe, 2002).
- Element Occurrence: An occurrence with practical conservation value as determined by a combination of Conservation Status Rank (rarity and imperilment of the ecosystem across its range) and EIA Rank (condition of the specific occurrence).
- Assessment Area (AA): The spatial area in which the EIA will be applied. The AA is "the entire area, subarea, or point of an occurrence" of an ecosystem type "with a relatively homogeneous ecology and condition" (Faber-Langendoen et al., 2016a,b,c).
- Spatial Pattern Type: Refers to the scale at which an ecosystem naturally occurs on the landscape. For example, 'matrix' types of vegetation are dominant across the majority of a given landscape, while 'large-patch', 'small-patch', and 'linear' types occur as distinctive patches within the larger 'matrix.'
- Ecosystem: Used in a generic sense, referring to Ecological Systems, USNVC Groups, USNVC Associations, etc.—really any ecosystem classification unit.

- Ecological Systems: A mid-scale ecological classification developed by Comer et al. (2003) to aid conservation and environmental planning for uplands and wetlands. Ecological Systems represent recurring groups of terrestrial plant communities found in similar climatic and physical environments (including substrates and/or environmental gradients) and influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al., 2003).
- United States Vegetation Classification (USNVC): A comprehensive, hierarchical classification of ecosystems of the United States (http://www.usnvc.org), developed in conjunction with the International Vegetation Classification (IVC) (http://www.natureserve.org/conservation-tools/projects/international-vegetation-classification). Both classifications are based on vegetation criteria (physiognomy and structure, plant species composition) and ecological characteristics, including disturbance patterns, bioclimate, and biogeography (Faber-Langendoen et al., 2009, 2014). USNVC hierarchy units mentioned in this document:
    - Group: "A vegetation classification unit that is defined by a relatively small set of diagnostic plant species (including dominants and codominants), broadly similar composition, and diagnostic growth forms that reflect regional mesoclimate, geology, substrates, hydrology, and disturbance regimes" (Faber-Langendoen et al., 2014).
    - Association: "A vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. Associations reflect subregional to local topo- edaphic factors of substrates, hydrology, disturbance regimes, and climate" (Faber-Langendoen et al., 2014).
- EIA Module: For the purposes of Level 2 EIA, Washington's Ecological Systems have been aggregated into physiognomically similar "modules" that share key ecological processes, such as climate, broad disturbance regimes, soil types, etc. It is not a systematic vegetation classification unit, but a means of grouping ecosystems that can be evaluated by the same EIA metrics.

2.0 APPLYING LEVEL 2 ECOLOGICAL INTEGRITY ASSESSMENTS

2.1 MATERIALS

In addition to standard footwear and attire for working in the field, the following materials and supplies are needed for applying the EIA:

- EIA field forms (http://www.dnr.wa.gov/NHPdata)
- *Ecological Systems of Washington State. A Guide to Identification* (Rocchio & Crawford, 2015) (http://www.dnr.wa.gov/NHPecoreports)
- Local plant identification keys and field guides. Users are strongly encouraged to use technical dichotomous keys such as *Flora of the Pacific Northwest* (Hitchcock & Cronquist, 1973). Color photo field guides typically list only common species. While they are an indispensable tool for identification, they do not cover the entire flora.
- *Identifying Old Trees and Forests in Eastern Washington* (Van Pelt, 2008) (http://file.dnr.wa.gov/publications/lm_hcp_west_oldgrowth_guide_full_lowres.pdf)
- *Identifying Mature and Old Forests in Western Washington* (Van Pelt, 2007) (http://file.dnr.wa.gov/publications/lm_hcp_east_old_growth_hires_part01.pdf)
- Hand lens, compass, camera, small trowel or shovel, pin flags and/or flagging, measuring tape (for plot layout)
- GIS is recommended for assessing Landscape Context and Edge metrics. However, using online map viewers could suffice. We have adapted NatureServe's Ecological System's map (http://www.natureserve.org/conservation-tools/terrestrial-ecological-systems-united-states) for assessing land use patterns and scoring EIA metrics. The GIS layer can be downloaded here: https://fortress.wa.gov/dnr/adminsa/DataWeb/dmmatrix.html#Natural Heritage.

2.2 PROCEDURE

Below are general guidelines for applying a Level 2 EIA.

Step 1: Determine project objectives: Is your objective to estimate condition of an Ecological System (or other classification unit) across a given watershed, ecoregion, or management area, or to estimate condition of a specific occurrence?

Step 2: Assemble background information about ecological and management history of the site or project area.

Step 3: Classify the ecosystem occurrences present at the site using the Key to Washington's Ecological Systems found in Rocchio & Crawford (2015). If assessing riparian or wetland ecosystem occurrences, STOP and switch to the EIA manual for wetlands and riparian areas (Rocchio et al., 2016)

Step 4: Identify assessment area(s) of the occurrences. Each assessment area must contain only one ecosystem occurrence. In some cases, the assessment area (AA) equals the full extent of the occurrence within the project area, but it may be smaller. See Sections 2.3 and 2.4 for details.

Step 5: Estimate the size of the AA. If > 50 ha, it is a Large AA. If < 50 ha, it is a Small AA. The AA size, along with the EIA module, will determine which methodology and EIA metrics to use during the assessment.

Step 6: Make sure the AA meets the minimum size requirement (Table 2) for the spatial pattern type of the Ecological System (see Rocchio & Crawford (2015)).

Step 7: Using Table 4, determine the EIA module in which the Ecological System is classified. Along with AA size, the EIA module determines which set of ecologically specific EIA metrics to use during the assessment.

Step 8: Using GIS, establish the Landscape Context envelope for the AA by buffering a 500 m area around the outer AA boundary. Also, establish an Edge envelope for the AA by buffering an area (100 m for all AA sizes) around the outer AA boundary.

Step 9: Before implementing the assessment, consult metric protocols to ensure they are conducted systematically. Verify the appropriate season to sample in and/or other timing aspects of field assessment (Section 3.0 Level 2 EIA Protocol). If returning to a long-term monitoring site, be sure to match seasonality as much as possible with the timing of previous site visits.

Step 10: Some metrics may be entirely or partially based on office assessments. When possible, complete those prior to field work.

Step 11: Determine your sampling strategy. The assessment often follows a site walkthrough approach where metrics are scored based on visual observations. For long-term monitoring, relevé plots are recommended for collecting data necessary to score metrics. For Large AAs (> 50 ha), where the AA is too extensive to assess rapidly and confidently, employ a point-based or combined point/polygon-based sampling methodology (Figure 2), with multiple assessment points selected at random before the field visit.

Step 12: Conduct the field assessment of on-site conditions, scoring all applicable metrics and noting stressors on the AA(s). For Small AAs (< 50 ha), the entire AA should be assessed, including—as much as feasibly possible—the 100 m Edge that extends beyond the AA boundary. This is typically aided by aerial photography or other imagery. For Large AAs (> 50 ha)—where it is not feasible to observe the entire occurrence with a rapid site walkthrough approach—sample the pre-determined assessment points.

Step 13: Complete the roll-up calculations for the six Major Ecological Factors, three Primary Rank Factors, and overall EIA ranks/scores. Automated EIA calculators are available on the WNHP website (http://www.dnr.wa.gov/NHP-EIA).

Step 14: Using the conservation status rank of the Ecological System being assessed (consult Rocchio & Crawford (2015)) and the overall EIA rank of the AA, refer to Table 3 and determine whether the occurrence meets the WNHP standard for an Element Occurrence. If so, submit EIA documentation to WNHP when convenient.

2.3 Assessment Area

As mentioned above, the Assessment Area (AA) is the spatial area in which the EIA will be applied. The AA is "the entire area, subarea, or point of an occurrence" of an ecosystem type "with a relatively homogeneous ecology and condition" (Faber-Langendoen et al., 2016a,b,c). An individual AA must contain only one ecosystem type at the desired scale of classification. In other words, when using Ecological Systems as the target, the AA may contain only one Ecological System. When using United States National Vegetation Classification (USNVC) plant associations (http://usnvc.org) as the target level of classification, the AA may contain only one association. The AA may never be larger than the occurrence being assessed, but it *is* possible for the AA to be smaller than the occurrence. This may occur due to a property line, or when different portions of the occurrence have starkly different anthropogenic histories. For example, a fenceline may cross an occurrence, limiting grazing to one side and resulting in very different ecological condition on either side.

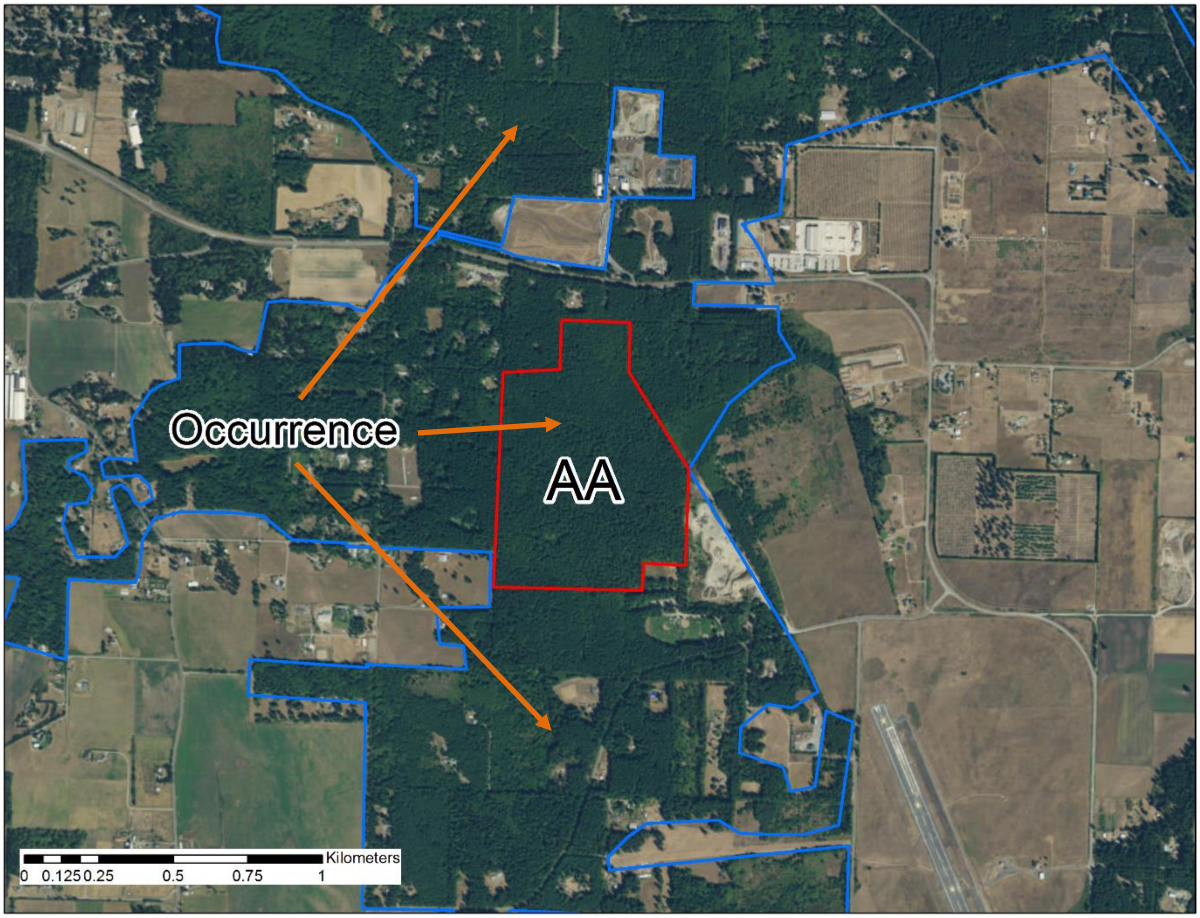

Figure 1. Example of Assessment Area (AA) v. Occurrence. The full extent of this North Pacific Maritime Dry-Mesic Douglas-Fir Western Hemlock Forest is the occurrence. The AA is the area in which the EIA will be applied. In this demonstration, the AA is smaller than the occurrence because the EIA is being applied to a county park. The area within the county park has relatively homogeneous ecology and condition, but outside its borders (throughout the rest of the occurrence) there is an amalgamation of different management histories that have resulted in a range of conditions.

There are many different approaches for determining the AA boundary, contingent on project objectives, ecosystem target, and the size of the occurrence. The approaches for AA delineation can generally be grouped into four categories: (1) point-based, (2) polygon-based, (3) combined point/polygon-based, and (3) nested polygon-based (using sub-AAs). Sections 2.3.1 through 2.3.4 outline each of these four approaches. Consult Figure 2 for guidance on the appropriate approach for your project objectives.

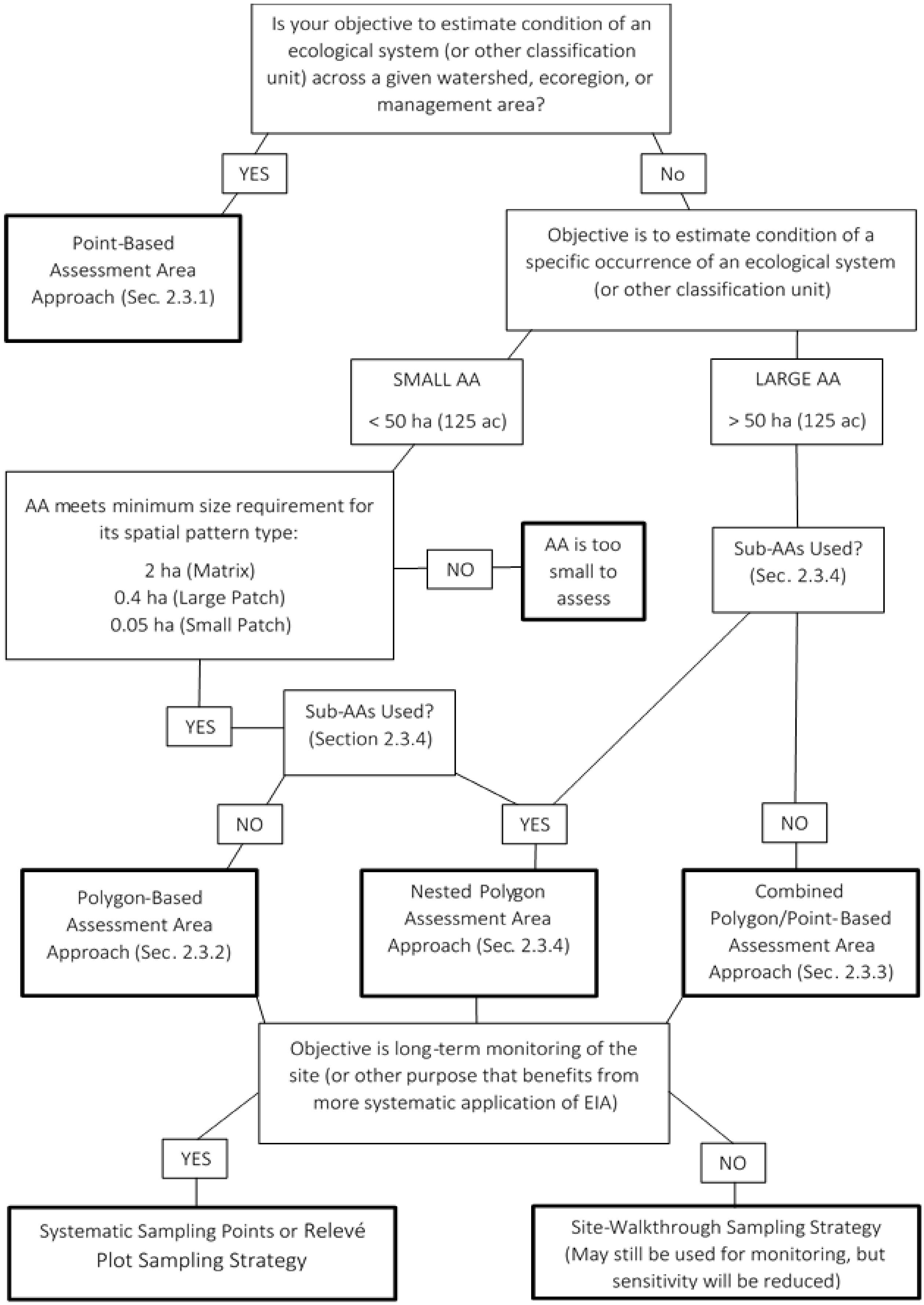

Figure 2. Decision Tree for Selection of Assessment Area Approach and Sampling Strategy

2.3.1 Point-Based Assessment Area

Point-based approaches are best suited for assessing the ecological condition of a population of occurrences, such as occurrences of a given ecosystem across an entire watershed or ecoregion (see Figure 2). These approaches typically define a relatively small area (e.g., 0.5 ha) around pre-determined points that are randomly distributed across the geographical area of interest. Assessments are then conducted within and around these points. A point-based approach offers some advantages (Fennessy et al., 2007; Stevens Jr & Jensen, 2007):

- Simple sampling design.
- Does not necessarily require a mapped boundary of the ecosystem
- Limited practical difficulties in the field for assessing the entire area, as the area is typically relatively small (0.5–2 ha).
- Long-term ambient monitoring programs often use a point-based approach because of these advantages.

For point-based AAs, some EIA metrics may not be applicable (e.g., Size metrics) or require modifications to rating criteria and/or roll-up procedures to make them logically consistent with their development. Those modifications are not within the scope of this document. Please contact WNHP for more information about using point-based sampling for EIAs in this context.

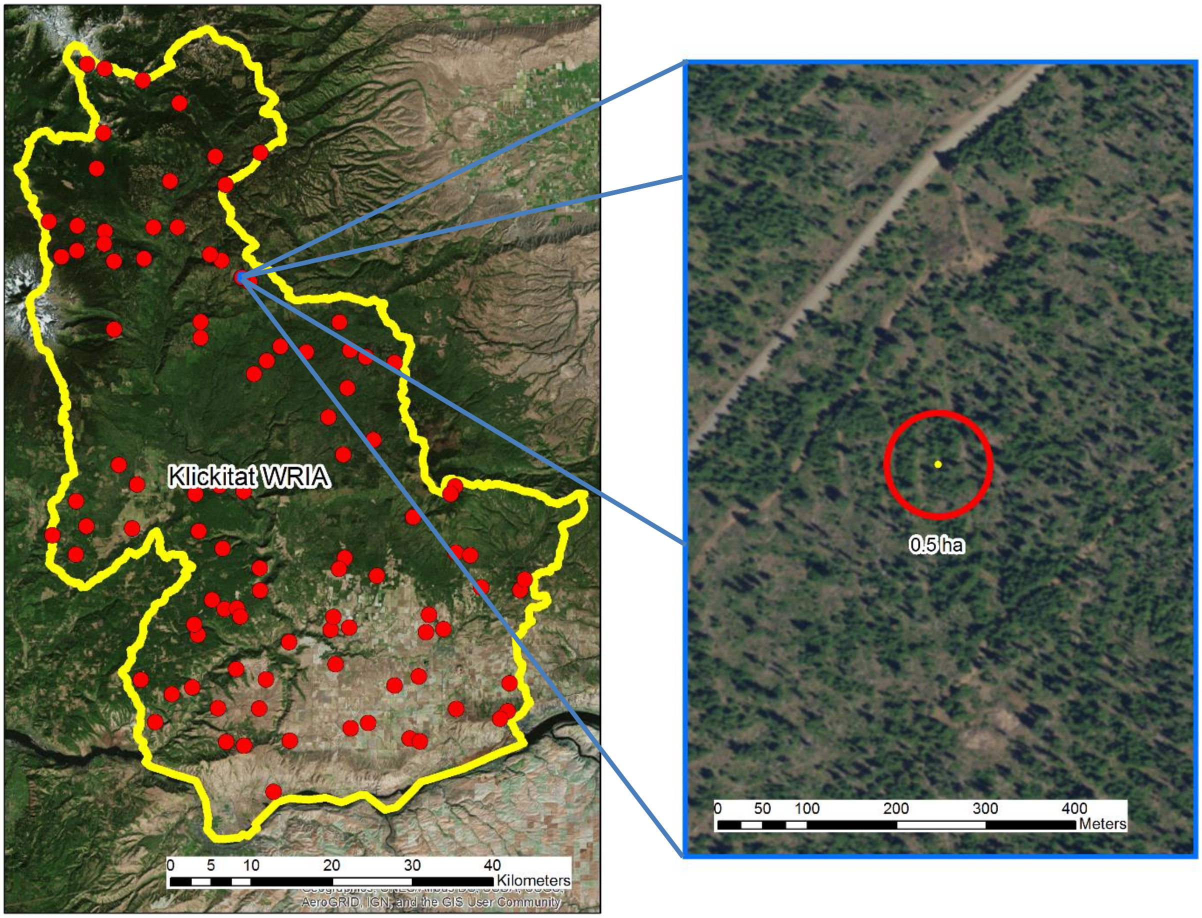

Figure 3. Point-based Assessment Areas (red circles). 40 m buffers were applied to randomly distributed points to create 0.5 ha assessment areas across an entire Water Resource Inventory Area (WRIA, http://www.ecy.wa.gov/programs/eap/wrias/Planning/). Points that fall within the ecological system of interest are then sampled.

2.3.2 Polygon-Based Assessment Area

The polygon approach is best suited for assessment of small AAs (< 50 ha) (see Figure 2). This includes nearly all occurrences of small-patch Ecological Systems, in addition to small occurrences of large-patch and matrix types (see Table 1). These AAs can be sampled using a site walkthrough approach whereby the observer walks as much of the AA as possible and makes observations that are then synthesized into metric ranks. Another option is to use a series of relevé plots or systematic sampling points within the AA where Condition metrics are assessed (similar to the combined point/polygon-based approach described in Section 2.3.3). The latter approach is useful for long-term monitoring (returning to the same plots each time) or to ensure a more systematic application of the EIA. It is *possible* to use polygon-based AAs to estimate ecological condition of larger aggregations of occurrences, or for occurrences of large-patch or matrix Ecological Systems, but the combined point/polygon method (Section 2.3.3) is typically more efficient and more conducive to those applications. Advantages of polygon-based AAs are:

- Mapping boundaries facilitate whole ecosystem and landscape interpretations.
- Decision-makers and managers are often more interested in "stands" or "occurrences," than points.
- Programs that maintain mapped occurrences of ecosystems are most interested in the status and trends of those occurrences.

Table 1. Patch Type Definitions (Comer et al., 2003).

PATCH TYPE	DEFINITION
Matrix	Ecosystems that form extensive and contiguous cover, occur on the most extensive landforms, and typically have wide ecological tolerances. Disturbance patches typically occupy a relatively small percentage (e.g., < 5%) of the total occurrence. In undisturbed conditions, **typical occurrences range in size from 2,000–10,000 ha (5000 – 25,000 ac) or more.**
Large Patch	Ecosystems that form large areas of interrupted cover and typically have narrower ranges of ecological tolerances than matrix types. Individual disturbance events tend to occupy patches that can encompass a large proportion of the overall occurrence (e.g., > 20%). Given common disturbance dynamics, these types may tend to shift somewhat in location within large landscapes over time spans of several hundred years. In undisturbed conditions**, typical occurrences range from 50–2,000 ha (125-5,000 ac).**
Small Patch	Ecosystems that form small, discrete areas of vegetation cover, typically limited in distribution by localized environmental features. In undisturbed conditions, **typical occurrences < 50 ha (< 125 ac).**
Linear	Ecosystems that occur as linear strips. They often form ecotones between terrestrial and aquatic ecosystems. In undisturbed conditions**, typical occurrences range in linear distance from 0.5–100 km (1 – 60 mi).**

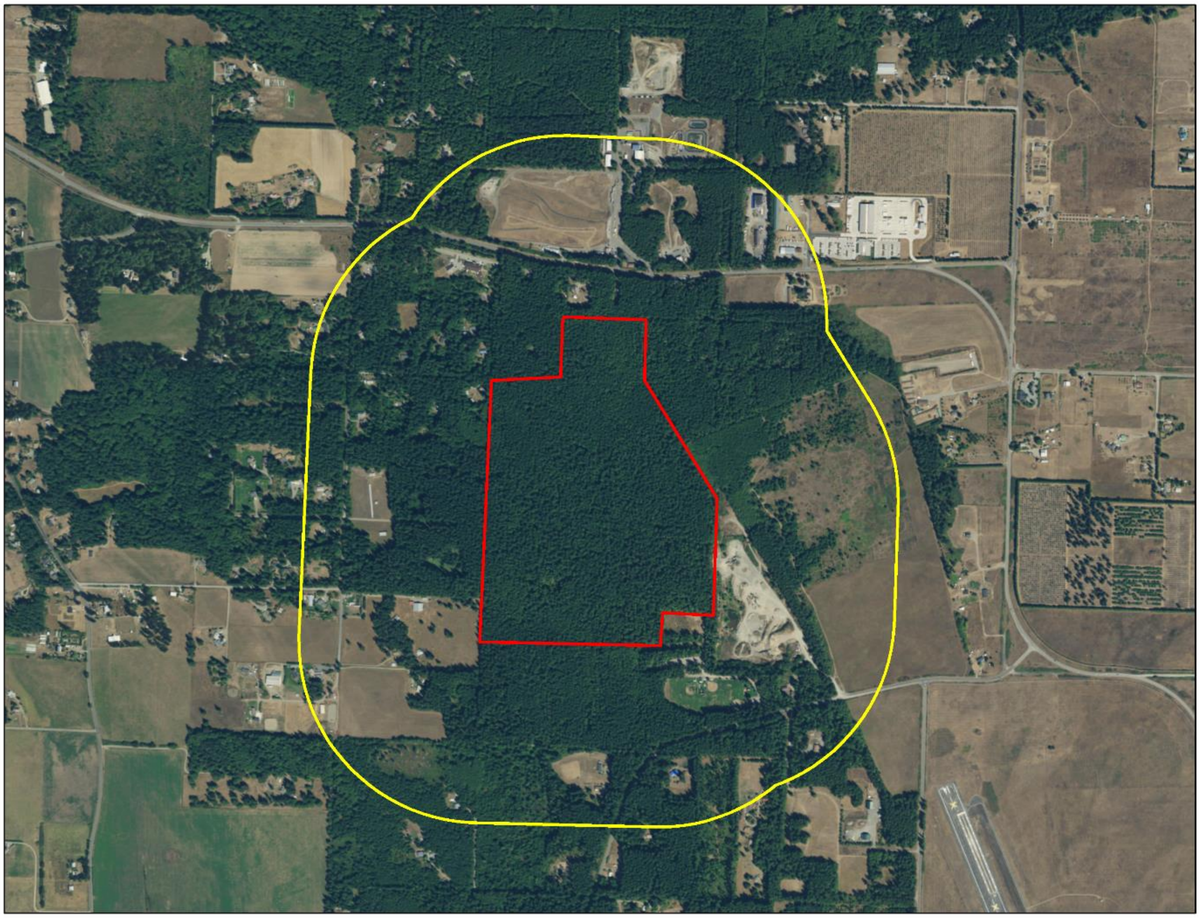

Figure 4. Polygon-based Assessment Area (red line) and 500 m Landscape Context Envelope (yellow line).

2.3.3 Combined Point/Polygon-Based Assessment Areas for Large-Patch and Matrix Ecological Systems

In this document we introduce a method for using combined point/polygon-based assessment areas for use in large AAs (> 50 ha) (see Figure 2). This method differs from the strict polygon-based approach in the following ways:

- A polygon-based assessment area boundary is mapped, but only used for Landscape Context and Size metrics.
- For Condition metrics, multiple point-based AAs are made within the larger polygon-based AA boundary. Each applicable Condition metric is rated/scored at each point-based AA. These multiple point-based AA ranks/scores are then rolled-up in order to calculate an overall score for a given metric over the entire polygon-based AA. This process ultimately provides a rank/score for each Condition metric at the polygon-based AA scale. Thereafter, Condition, Landscape Context, and Size metrics are rolled-up using the same approach as the polygon-based approach.

- Gives a structured sampling approach for assessing Ecological Systems that occur over vast areas.

Note that large AAs are used to assess most—but not all—large-patch or matrix Ecological System occurrences. Small occurrences of these systems should be assessed using the polygon-based methodology of small AAs (section 2.3.2), which allows for greater sampling efficiency. This applies to both naturally small/confined occurrences of large-patch and matrix Ecological Systems (e.g. occurring on the edge of the system's natural geographic range, or the site is restricted by soils, geology, aspect, etc.), as well as anthropogenically reduced fragments. From an ecological perspective, Size metrics for these small fragments will be scored relative to the inherent patch size of their Ecological System.

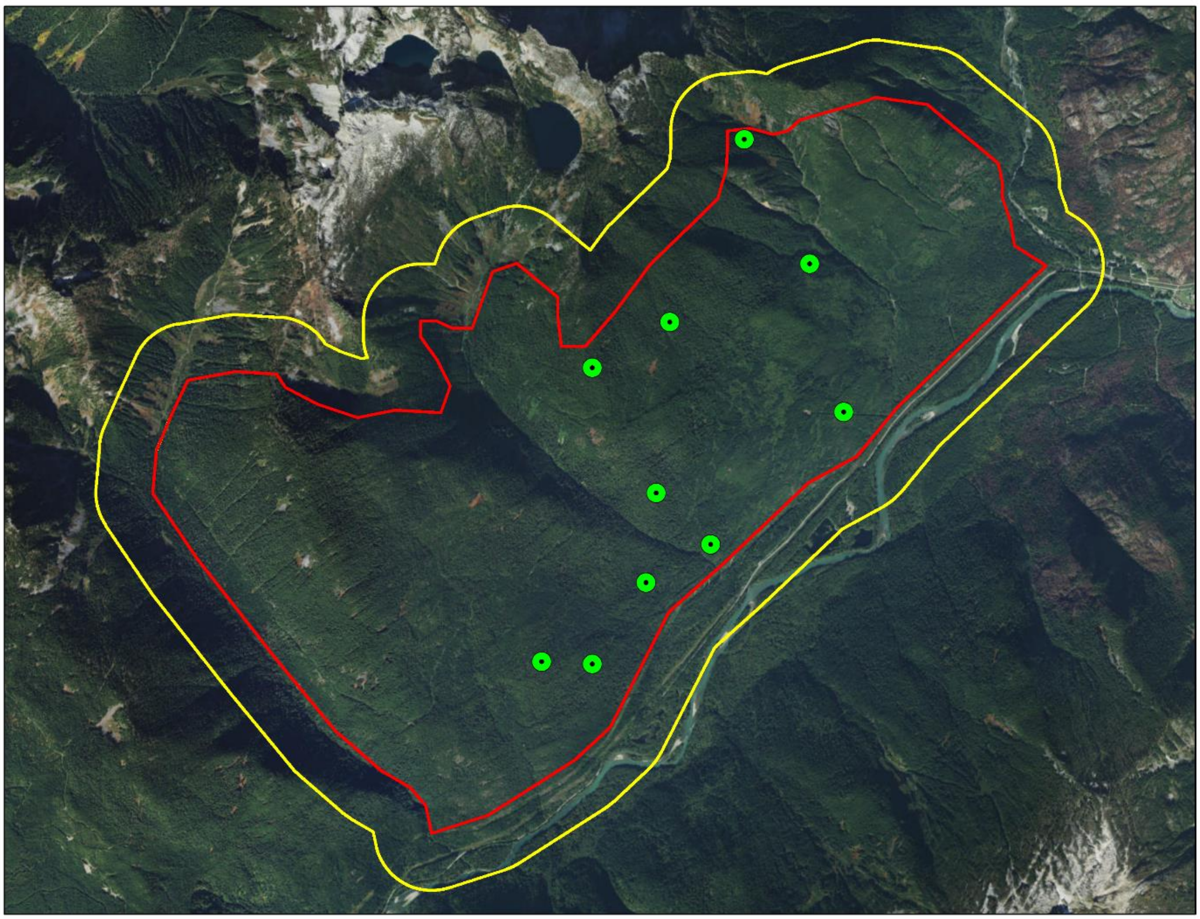

Figure 5. Combined Point/Polygon-Based Assessment Area (red line), 500 m Landscape Context Envelope (yellow line), and Randomly Distributed Assessment Points (green dots) for Large AAs.

2.3.4 Nested Polygon-Based Assessment Areas for Use with Sub-AAs

Another method for making large AAs more practicable is to divide them into multiple polygons that can be evaluated as "sub-assessment areas" (sub-AAs). Note that the entire occurrence remains one AA, because it is all one ecosystem type and the management histories of the different sections are not notably different. Sub-AAs may be delineated via numerous methods: randomly, based on observed ecological condition, using natural topographic breaks, the amount of area one can survey in a day, etc. Sub-AAs may be delineated on the ground, but are more easily determined beforehand using aerial imagery.

Besides making the sampling effort more practicable, some users may be interested in scoring individual sections within a larger AA for management purposes. For example, if a manager's goal is to restore the entirety of a forested ecosystem occurrence to old-growth conditions, they may have already digitized areas that are in early seral states in order to track progress of those sections towards old-growth. These pre-delineated sections can be considered sub-AAs for the purpose of the EIA.

This approach may be used with AAs of any size, but it will take considerable sampling effort to deploy it with large AAs. It differs from the strict polygon-based approach in the following ways:

- An outer assessment area boundary is mapped, but only used for Landscape Context and Size metrics.
- For Condition metrics, multiple sub-AAs are created within the larger AA boundary based on management units, "stands", or other user criteria. Each applicable Condition metric is rated/scored within each sub-AA, using either a site-walkthrough or systematic sampling approach. These sub-AA rank/scores are then weighted based on the area of the sub-AA relative to the full AA and rolled-up in order to calculate an overall score for a given metric over the entire polygon-based AA. This process ultimately provides a rank/score for each Condition metric at the AA scale, but the individual sub-AA ranks/scores may be used for management purposes. Thereafter, Condition, Landscape Context, and Size metrics are rolled-up using the same approach as the polygon-based approach.
- Gives a structured sampling approach for assessing the condition of smaller patches within an AA.

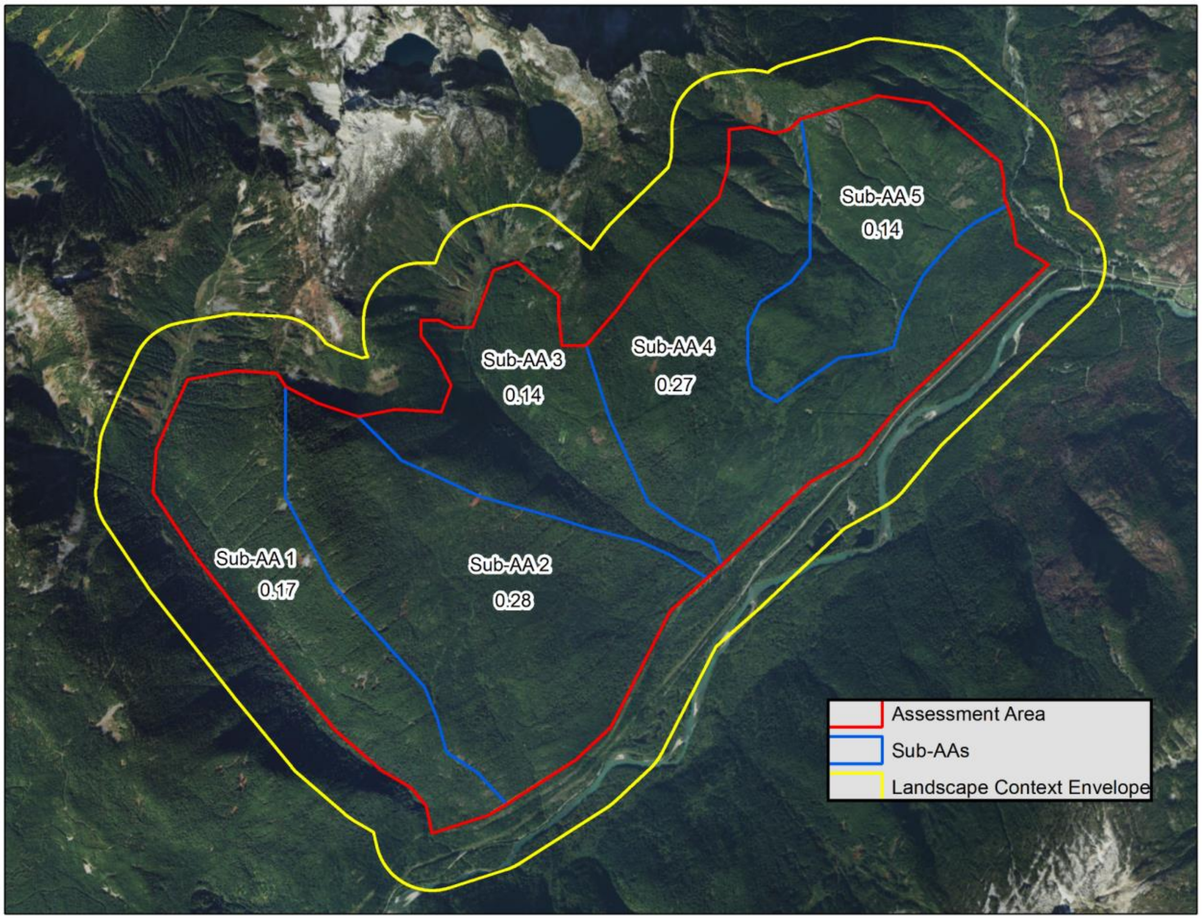

Figure 6. Nested Polygon-Based Assessment Area (red line), sub-AAs (blue line), and 500 m Landscape Context Envelope (yellow line). The numbers indicate proportion of the total AA accounted for by each sub-AA. Each sub-AA is scored for Condition metrics separately, then multiplied by its proportion of the total AA area. The sum of these weighted scores then gives the total score for that metric over the whole AA.

2.4 Determine the Assessment Area Boundaries

The steps below outline the procedure for delineating an AA boundary.

Step 1. Estimation of Ecosystem Occurrence Boundaries: Classify the ecological systems present within your project area (using Rocchio & Crawford (2015)) and then map their extent. These boundaries form the first draft of your AAs. In some cases, the extent of a given Ecological System may consist of multiple polygons that are separated from one other.

Make sure each AA meets the minimum size requirement (Table 2) for the spatial pattern type of the Ecological System (see Rocchio & Crawford (2015)). Consider an example in which you have mapped Inter-Mountain Basins Semi-Desert Shrub-Steppe (a matrix system), but the AA is only 1 ha in size. The AA does not meet the minimum size requirement for that spatial pattern type and thus is not considered to be a viable example of the ecosystem—it would not be assessed. In this case, the small remnant is considered either a) variation in the ecosystem type within which it is embedded, or b) a very small fragment of a once larger occurrence that is now too small to possess the ecological characteristics of the ecosystem in question. However, if your project objectives require such remnants to be assessed, the default score should be an overall "D" rank. Users may still use individual metrics to track specific attributes in such areas, if desirable.

Table 2. Patch Type and Minimum Size.

Patch Size of Ecological System Target	Recommended Minimum Size for Assessment Area
Matrix	2 ha (~5 acres)
Large Patch	0.4 ha (~1 acre)
Small Patch	0.05 ha (500 m^2)

If you are interested in submitting your ecological observation to WNHP for consideration as an element occurrence, proceed to step 2. Otherwise, skip to step 3.

Step 2. Preliminary Determination of the Ecological System's Conservation Significance

To merit consideration as a WNHP element occurrence (EO), the occurrence must be a rare ecosystem or a common one with excellent ecological integrity (Table 3). This is determined using the conservation status rank (Global/State rank) of the ecosystem and the EIA rank of the specific occurrence of that type. In other words, all occurrences of rare ecosystems qualify, regardless of their condition, while only good to excellent condition examples of common types are tracked as EOs.

Before proceeding further with the EIA, one should make a preliminary determination of whether the specific occurrence in question may qualify as an EO. First, determine the conservation status rank of the ecosystem target being assessed. If focusing on Ecological Systems, consult Rocchio & Crawford (2015), otherwise see the appropriate plant association field guide (http://www.dnr.wa.gov/NHPecoreports) and lists (http://file.dnr.wa.gov/publications/amp_nh_assoc_list.pdf). If it is a common ecosystem (e.g., S4 or S5), use your professional judgment regarding the ecological condition of the occurrence to determine whether it is valuable to proceed further. For example, if the ecosystem target is part of the North Pacific Mountain Hemlock Forest Ecological System (conservation status rank = S4S5) and it appears significantly degraded, further assessment is probably unnecessary, since occurrences of S4S5 ecosystems must have an A-rank or "excellent integrity" to be tracked as element occurrences (Table 3). If there is reason to believe the occurrence could have excellent ecological integrity (e.g., A-rank) then continue to Step 4. Conversely, if the occurrence is part of an ecosystem with a conservation status rank of G1 or S1, then further assessment is certainly warranted, as any occurrence with that status would warrant tracking as an EO, regardless of EIA rank (Table 3). This same logic applies to plant associations.

Table 3. Decision Matrix to Determine Ecosystem Element Occurrences.

Global / State Conservation Status Rank Combination	Ecological Integrity Assessment Rank			
	A Excellent Integrity	B Good Integrity	C Fair Integrity	D Poor Integrity
G1S1, G2S1, GNRS1, GUS1				
G2S2, GNRS2, G3S1, G3S2, GUS2				
GUS3, GNRS3, G3S3, G4S1, G4S2, G5S1, G5S2, any SNR				
G4S3, G4S4, G5S3, G5S4, G5S5, GNRS4, GNRS5, GUS4, GUS5				
Red Shading = Element Occurrence				

<u>Step 3. Aggregate Polygons into AA Boundaries</u>: If each ecosystem target identified in Steps 1-2 has only one polygon/patch, then proceed to Step 4. Otherwise, use the key below to determine whether to aggregate multiple polygons of the same vegetation type as a single AA or to consider them as separate AAs.

1. Is the distance between two separate observation ≥ 5km?
   Yes = they are separate AAs
   No – GO TO 2
2. Do the observations share connected habitat?
   Yes = GO TO 3
   No – GO TO 4
3. Is there an area of cultural vegetation/development ≥ 2 km long (following linear habitat) between observations?
   Yes = they are separate AAs
   No – they are the same AA
4. Is there an area of development ≥ 100 m wide?
   Yes = they are separate AAs
   No – GO TO 5
5. Is there cultural vegetation / water ≥ 300 m wide?
   Yes = they are separate AAs
   No – GO TO 6
6. Is there contrasting wetlands / uplands ≥ 500 m wide? (i.e., if element is upland, contrast = wetland, and vice-versa)
   Yes = they are separate AAs
   No – they are same AA

<u>Step 4. Modifications to AA Boundaries Based on Variation in Land Use:</u> If significant changes in management or land use results in distinct ecological differences within the occurrence boundaries identified in Steps 1-3, those areas should be considered separate AAs (e.g. heavily

grazed shrub-steppe on one side of a fence line and ungrazed shrub-steppe on the other could result in separate AAs, even if they are both part of the same ecosystem target).

<u>Step 5. Apply Level 2 EIA to AA Boundaries</u>: For small occurrences, the extent of the AA boundary at this stage will result in a reasonably sized area (< 50 ha) allowing practical application of the EIA. If the AA exceeds a reasonable size for a rapid assessment (the AA > 50 ha), consider: (1) creating sub-AAs so that each is a practical assessment unit for a site walkthrough approach OR (2) use the combined point/polygon approach (Section 2.3.3.) to sample the AA. Our initial recommendation—pending further testing and statistical analysis—is to randomly establish 10 assessment points of 0.5 ha each (as in US Environmental Protection Agency, 2016) within the mapped boundary of the AA polygon (this can be done using GIS). These can be 40 m radius circular plots or rectangular plots of appropriate dimensions. Landscape Context and Size metrics are scored for the AA polygon as a whole, while all other metrics are scored for the individual assessment points and then averaged across the entire AA (as outlined in section 2.3.3). It is important to balance the goal of representing the inherent variability of large occurrences with the need to conduct efficient field sampling. Note that assessment points that fall within ecosystem inclusions (areas that differ from the ecosystem target being assessed) should be thrown out and new points should be selected. Note that sub-AAs may also be used as part of the nested polygon approach, in cases where managers are interested in scoring individual portions of a larger AA.

2.5 Determine Which Metrics to Apply

AA size is one key factor in determining which metrics to use in the Level 2 EIA. The other factor is the “EIA module” of the Ecological System being assessed. For the purposes of Level 2 EIA, Washington’s Ecological Systems have been aggregated into physiognomically similar modules that share key ecological processes, such as climate, broad disturbance regimes, soil types, etc. Because each AA represents a single Ecological System, by definition, an AA also represents only one EIA module. Consult Table 4 to determine which EIA module your AA’s Ecological System falls within. Once you’ve identified the EIA Module and size of your AA, consult Table 5 to determine which metrics or ratings to apply. Some metrics that cover complicated concepts have been broken down into component submetrics that allow the user to score the metric piece-by-piece. Generally, the total metric score is the average of all of its submetrics, unless stated otherwise (for example, VEG 1 Native Plant Species Cover takes the lowest value between the Tree and Shrub/Herb strata submetrics).

Table 4. Ecological System to EIA Module Crosswalk.

Ecological System	EIA Module
Columbia Basin Foothill and Canyon Dry Grassland	Grasslands / Meadows
Columbia Basin Palouse Prairie	Grasslands / Meadows
Columbia Plateau Low Sagebrush Steppe	Shrub-Steppe
Columbia Plateau Scabland Shrubland	Shrub-Steppe
Columbia Plateau Steppe and Grassland	Grasslands / Meadows
Columbia Plateau Western Juniper Woodland and Savanna	Dry Forests & Woodlands
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	Mesic / Hypermaritime Forests
East Cascades Oak-Ponderosa Pine Forest and Woodland	Dry Forests & Woodlands
Inter-Mountain Basins Active and Stabilized Dune	Grasslands / Meadows
Inter-Mountain Basins Big Sagebrush Steppe	Shrub-Steppe
Inter-Mountain Basins Cliff and Canyon	Bedrock / Cliff
Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	Shrublands
Inter-Mountain Basins Montane Sagebrush Steppe	Shrub-Steppe
Inter-Mountain Basins Semi-Desert Shrub-Steppe	Shrub-Steppe
North Pacific Active Volcanic Rock and Cinder Land	Bedrock / Cliff
North Pacific Alpine and Subalpine Bedrock and Scree	Bedrock / Cliff
North Pacific Alpine and Subalpine Dry Grassland	Grasslands / Meadows
North Pacific Avalanche Chute Shrubland	Shrublands
North Pacific Broadleaf Landslide Forest and Shrubland	Mesic / Hypermaritime Forests
North Pacific Coastal Cliff and Bluff	Bedrock / Cliff
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field, or Meadow	Shrublands
North Pacific Dry Douglas-fir Forest and Woodland	Dry Forests & Woodlands
North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest	Mesic / Hypermaritime Forests
North Pacific Herbaceous Bald and Bluff	Grasslands / Meadows
North Pacific Hypermaritime Shrub and Herbaceous Headland	Bedrock / Cliff
North Pacific Hypermaritime Sitka Spruce Forest	Mesic / Hypermaritime Forests
North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest	Mesic / Hypermaritime Forests

Ecological System	EIA Module
North Pacific Maritime Coastal Sand Dune	Grasslands / Meadows
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	Mesic / Hypermaritime Forests
North Pacific Maritime Mesic Subalpine Parkland	Mesic / Hypermaritime Forests
North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest	Mesic / Hypermaritime Forests
North Pacific Mesic Western Hemlock-Silver Fir Forest	Mesic / Hypermaritime Forests
North Pacific Montane Massive Bedrock, Cliff and Talus	Bedrock / Cliff
North Pacific Montane Shrubland	Shrublands
North Pacific Mountain Hemlock Forest	Mesic / Hypermaritime Forests
North Pacific Oak Woodland	Dry Forests & Woodlands
North Pacific Serpentine Barren	Bedrock / Cliff
North Pacific Wooded Volcanic Flowage	Dry Forests & Woodlands
Northern Rocky Mountain Avalanche Chute Shrubland	Shrublands
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Mesic / Hypermaritime Forests
Northern Rocky Mountain Foothill Conifer Wooded Steppe	Dry Forests & Woodlands
Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland	Grasslands / Meadows
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Mesic / Hypermaritime Forests
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Shrublands
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Dry Forests & Woodlands
Northern Rocky Mountain Subalpine Deciduous Shrubland	Shrublands
Northern Rocky Mountain Subalpine Woodland and Parkland	Mesic / Hypermaritime Forests
Northern Rocky Mountain Subalpine-Upper Montane Grassland	Grasslands / Meadows
Northern Rocky Mountain Western Larch Savanna	Dry Forests & Woodlands
Rocky Mountain Alpine Bedrock and Scree	Bedrock / Cliff
Rocky Mountain Alpine Dwarf-Shrubland	Bedrock / Cliff
Rocky Mountain Fell-Field	Bedrock / Cliff
Rocky Mountain Alpine Turf	Grasslands / Meadows
Rocky Mountain Aspen Forest and Woodland	Mesic / Hypermaritime Forests
Rocky Mountain Cliff, Canyon and Massive Bedrock	Bedrock / Cliff
Rocky Mountain Lodgepole Pine Forest	Mesic / Hypermaritime Forests

Ecological System	EIA Module
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	Mesic / Hypermaritime Forests
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	Mesic / Hypermaritime Forests
Rocky Mountain Subalpine-Montane Mesic Meadow	Grasslands / Meadows
Willamette Valley Upland Prairie and Savanna	Grasslands / Meadows

Table 5. EIA Metrics and Applicable EIA Modules/AA sizes.

Primary Rank Factor	Major Ecological Factor	Metric/Variant Name	Where Measured	Apply to:
LANDSCAPE CONTEXT	LANDSCAPE	LAN1 Contiguous Natural Cover	Office then field check	All EIA modules and AA sizes (for large AAs, score entire AA, not assessment points)
		LAN2 Land Use Index	Office then field check	All EIA modules and AA sizes (for large AAs, score entire AA, not assessment points)
	EDGE	EDG1 Perimeter with Natural Edge	Office then field check	All EIA modules (all sizes; for large AAs, score entire AA, not assessment points)
		EDG2 Width of Natural Edge	Office then field check	All EIA modules (all sizes; for large AAs, score entire AA, not assessment points)
		EDG3 Condition of Natural Edge	Office then field check	All EIA Modules (small AAs)
CONDITION	VEGETATION	VEG1 Native Plant Species Cover	Field	All EIA modules (all sizes); Use lowest submetric score
		Submetrics: *Tree Stratum*		Forested EIA modules (all sizes)
		Shrub/Herb Stratum		All EIA Modules (all sizes)
		VEG2 Invasive Nonnative Plant Species Cover	Field	All EIA Modules (all sizes)
		VEG3 Native Plant Species Composition	Field	All EIA Modules (all sizes)
		VEG4 Vegetation Structure	Field	All EIA Modules (all sizes; variant differs by EIA Module)
		VEG4, variant 7		Dry Forests and Woodlands (all sizes)
		VEG4, variant 8		Mesic / Hypermaritime Forests (all sizes)
		VEG4, variant 9		Shrublands (all sizes)
		VEG4, variant 10		Shrub-Steppe (all sizes)
		VEG4, variant 11		Grasslands / Meadows (all sizes)

Primary Rank Factor	Major Ecological Factor	Metric/Variant Name	Where Measured	Apply to:
		VEG4, variant 12		Bedrock/Cliff (all sizes)
		VEG5 Woody Regeneration	Field	Forested EIA modules (all sizes; variant differs by EIA Module)
		VEG5, variant 2		Dry Forests and Woodlands (all sizes)
		VEG5, variant 3		Mesic / Hypermaritime Forests (all sizes)
		VEG6 Coarse Woody Debris, Snags, and Litter	Field	Required for Forested EIA Modules; Optional for Shrubland and Herbaceous EIA Modules (all sizes; variant differs by EIA Module)
		VEG6, variant 3		Dry Forests and Woodlands (all sizes)
		VEG6, variant 4		Mesic / Hypermaritime Forests (all sizes)
		VEG6, variant 5		Grasslands / Meadows (all sizes)
	SOIL	SOL1 Soil Condition	Field	All EIA Modules (all sizes)
		SOL1, variant 3		All EIA Modules (all sizes)
SIZE	SIZE	SIZ1 Comparative Size (Patch Type)	Office then field check	All EIA Modules (for large AAs, score entire AA, not assessment points)
		SIZ2 Change in Size (Optional)	Office then field check	Required for small AAs of large-patch ecosystems; optional for other small AAs

3.0 Level 2 EIA Protocol

This section provides guidance on how to populate the field form. The first four sections address basic site-level data. Thereafter, protocols for each metric are described. They are organized by Rank Factor categories. Some of the protocols are the same as outlined by Faber-Langendoen et al. (2016b, 2016c) and implemented in the Washington wetland/riparian EIA manual (Rocchio et al., 2016). Occasionally, regional language is used for some of the metric ratings. Additionally, many of the metric ratings have been updated/combined/modified from EIA scorecard matrices previously developed by WNHP for specific Ecological Systems (Crawford, 2011a-aj; Crawford & Rocchio, 2011; Rocchio, 2011a,b,c,d,e). This publication is the result of efforts to simplify those Ecological System-specific EIA scorecards into one document. After many years of employing the system-specific scorecards, it became obvious there were more similarities across systems than differences. This effort also matches a similar approach taken for wetland and riparian EIAs (Faber-Langendoen et al., 2016b, 2016c; Rocchio et al., 2016).

3.1 Site / Assessment Area Information

The EIA field form can be used with any of the three sampling approaches: (1) point-based; (2) polygon-based AA (small, < 50 ha) or (3) combined point/polygon AA (large, > 50 ha), as described in Section 2.3. The combined point/polygon method requires surveys of multiple assessment points, the field form accommodates this approach by providing columns for up to 10 sample points for applicable metrics. When using the polygon-based AA method, the entire AA is given one value per field/metric, so only assessment point 1 should be filled out in each table.

<u>Site Name</u>: Provide a unique name for the survey site or project area.

<u>AA Name (if > 1 AAs)</u>: If multiple assessment area polygons are established at the site, provide a unique name/identifier for the assessment area. For example, if there are multiple AA polygons at a site called "Pine Creek East" the individual AAs should be labeled something like "Pine Creek East-01" and "Pine Creek East-02". In this example, Pine Creek East-01 might be a high quality pine savanna occurrence, one side of a fence, while Pine Creek East-02 might be a much degraded, overgrazed pine savanna occurrence on the other side of the fence. Note that this naming convention does not apply to the multiple sample points one might establish within a single AA.

<u>Observer</u>: First and last name of the surveyor(s).

<u>Date</u>: Date(s) of the survey.

<u>County</u>: County in which the AA occurs.

<u>VegPlot(s)</u>: If vegetation plots are established within the AA, list their unique plot codes.

<u>TRS</u>: Township, Range, and Section in which the AA occurs.

Photos: If photos are taken, please provide the photographer's name and associated file names. File names, ideally, should have the photographer's initials and a numeric code (e.g., fjr_001). A brief description of each photo's content should be documented in (1) a field notebook, (2) the file name, or (3) in the photo's metadata.

EOID: This is the "element occurrence ID" code from BIOTICS. This only applies to existing records in Washington Natural Heritage Program's BIOTICS database.

Source FeatureID: This is the "Feature ID" code from BIOTICs. Element occurrences can have more than 1 polygon. The FeatureID is used to uniquely code each polygon. This only applies to existing records in WNHP's BIOTICS database.

Owner(s): List the owners of the AA.

Spatial Coordinates: Record coordinates and indicate the system used (LAT/LONG, UTMs, etc.). Space is provided on the field form to record coordinates for up to 10 sample point locations. If using a polygon-based, site walkthrough approach, record the AA coordinates under point 1 in the table.

Sampling Strategy: Indicate the method used to delineate the AA boundary.

Plot Type: Circle the type of plot used for data collection (write it in if not listed). The plot form is tailored for relevé or site walkthrough data collection.

Plot Size/Dimension: Note the size of the plots used. Standard plot sizes for specific strata include: 100 m^2 for herbaceous and shrubland ecosystems; 400 m^2 for forested ecosystems. Note size by dimension (e.g. 10x10 m; 20x20 m; 10x40 m, etc.). If the site walkthrough method is used, estimate area walked and approximate time spent searching.

AA Size: Record the estimated size of the AA in acres or hectares.

AA Description: Please provide a written description of the AA's characteristics. Focus on the setting in which the site occurs, ecological and vegetation patterns within and adjacent to the site, notable stressors or human activity, signs of wildlife, etc. A sketched map may also be helpful.

3.2 Environmental

Soil Type: Using the key in Figure 7 determine soil texture at approximately 15 cm depth.

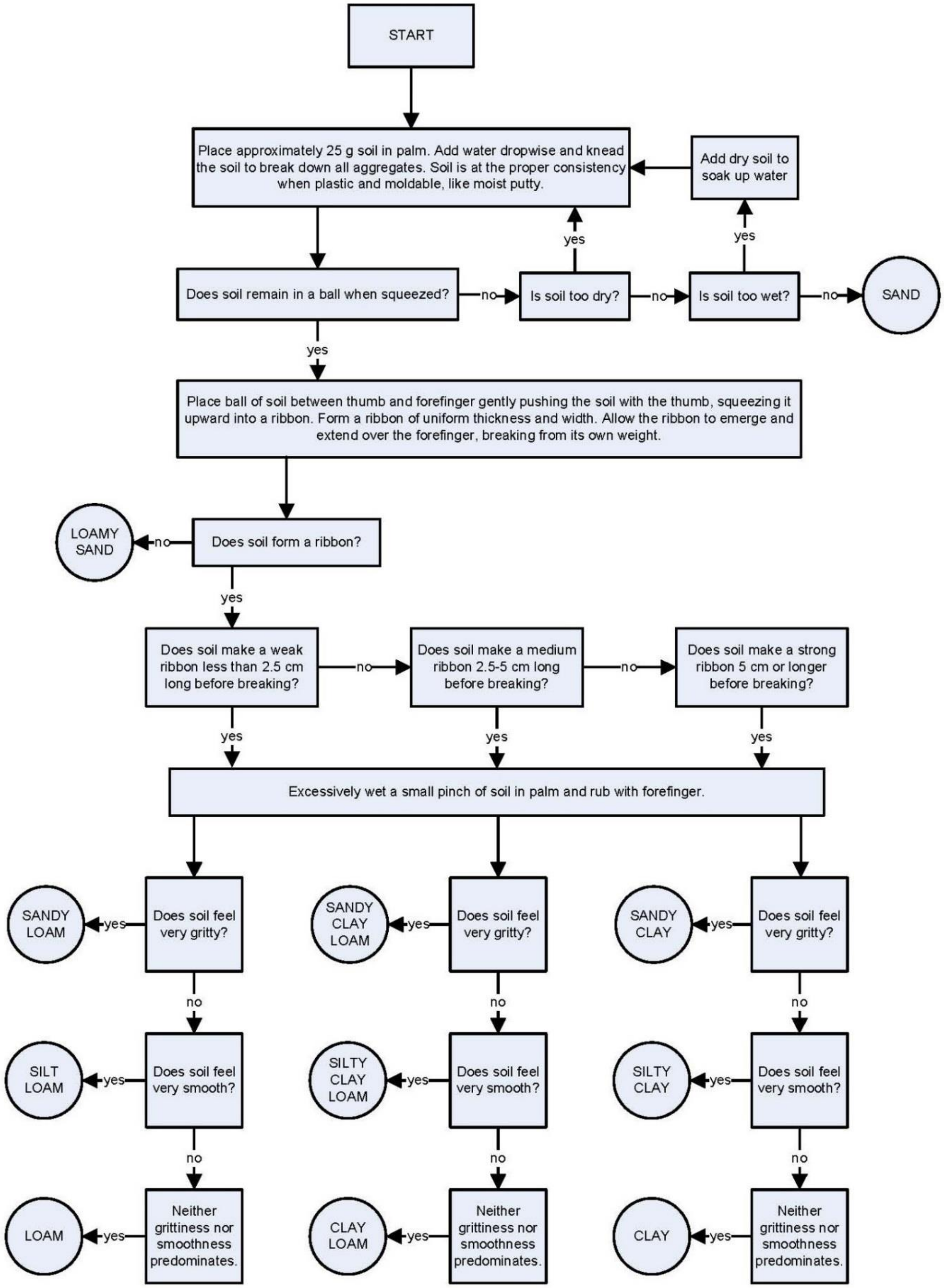

Figure 7. Soil Texture Flow Chart.

Topographic Position: Record the slope and aspect (facing downslope) and select the setting that best fits the location of the AA. If needed, use the empty boxes to enter topographic positions not represented in the table. Topographic positions are adapted from Liang (1951) and Dalrymple et al. (1968) and defined in Table 6.

Table 6. Topographic Positions.

Topographic Position	Definition
Interfluve	(Crest, summit, ridge): linear top of ridge, hill or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways
High Slope	(Shoulder slope, upper slope, convex creep slope): geomorphic component that forms the uppermost inclined surface at the top of a slope. It comprises the transition zone from backslope to summit, and the surface is dominantly convex in profile and erosional in origin
High Level	(Mesa) level top of plateau
Midslope	(Transportational midslope, middle slope): intermediate slope position between high and low
Backslope	(Dipslope): subset of midslopes which are steep, linear and may include cliff segments (fall faces)
Step in Slope	(ledge, terracette): nearly level shelf interrupting a steep slope, rock wall, or cliff face
Low slope	(Lower slope, foot slope, colluvial footslope): inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toeslope
Toeslope	(Alluvial toeslope): outermost gently inclined surface at base of a slope. Toeslopes in profile are commonly gentle and liner and characterized by alluvial deposition
Low level	(Terrace): valley floor or shoreline representing the former position of an alluvial plain, lake, or shore
Channel wall	(Bank): sloping side of a channel
Channel bed	(Narrow valley bottom, gully arroyo): bed of single or braided watercourse commonly barren of vegetation and formed of modern alluvium
Basin floor	(Depression): nearly level to gently sloping, bottom surface of an intermontane basin

Natural Disturbance Comments: Comments may include information on vegetation or ground cover disturbance (such as pit-and-mound topography created by windfall), evidence of native animal use, erosion, fire, storm debris, etc. If available, information on the type of disturbance, intensity, frequency, years of past disturbances, and seasonality may also be provided. Only comments on the natural disturbance evidence within the AA itself should be included in this field; although including information on the surrounding context cannot entirely be avoided, the focus should be on the AA. Information on disturbances to the surrounding landscape should be entered in the applicable Landscape Context metric comment fields instead.

Anthropogenic Disturbance Comments: Comments may include information on vegetation or ground cover disturbance by human activities such as logging, plowing, scraping, mowing, fire suppression, etc. If available, information on the type of disturbance, intensity, frequency, years of past disturbances, and seasonality may also be provided.

Geology Comments: Description of the geologic substrate that influences the occurrence.

Environmental Comments: Comments on other important aspects of the environment that affect this particular occurrence, including information on climate, seasonality, soil moisture, soil depth, or any other relevant environmental factors.

3.3 Classification

Ecological System: Note the Ecological System determined in Section 2.2 (using the key provided in Rocchio & Crawford (2015))

NVC Plant Association: Optional finer classification scale (Required for submission as EO).

NVC Group: Optional finer classification scale (Required for submission as EO).

Global/State Rank: Note the Global and State Conservation Status ranks for the Ecological System or NVC Plant Association.

EIA Module: Note the EIA module used (Table 4).

Stand Development Stage: In forested ecosystems, record the stand development stage using the keys in Van Pelt (2007, 2008).

3.4 Vegetation

Species Cover: List the species observed in the AA in the left hand column. For each species, enter the appropriate strata code. Columns for up to 10 relevé plots or assessment points are provided (if transect quadrats or nested subplots are used, attach the associated plot form to the EIA field form). Estimate canopy cover of the species within the plot and record the midpoint of the cover class (Table 7). For example, if *Artemisia tridentata* ssp. *vaseyana* has 10-25% cover, the midpoint value of 17.5 would be entered. Canopy cover is the "percentage of ground covered by a vertical projection downward of the outermost perimeter of the natural spread of foliage of plants" (Society for Range Management, 1989). Trace cover (0.25 midpoint) is assigned to minute plants that are found only once in the AA. If multiple plots are sampled, enter the average cover across plots for each species (this will help with metric calculations). For each species, be sure to enter the appropriate values for the Exotic/Invasive, Diagnostic, and Increaser/Decreaser columns. Example species for each of these categories, in each Ecological System, are found in Table A-1. Definitions of these categories are as follows:

Exotic species: Species not considered native to Washington.

Invasive species: Aggressive nonnative species that change or transform the character, condition, form, or nature of ecosystems (Monaco & Sheley, 2012).

Diagnostic species: The characteristic combination of native species whose relative constancy or abundance differentiates one vegetation type from another, including character species (strongly restricted to a type), differential species (higher constancy or abundance in a type as compared to others), constant species (typically found in a type, whether or not restricted), and dominant species (high abundance or cover) (Federal Geographic Data Committee, 2008). Together these species indicate specific ecological conditions--typically that of minimally disturbed sites.

Native Increaser Species: Native species that dramatically increase due to anthropogenic stressors such as grazing, nutrient enrichment, soil disturbance, etc. Examples, along with sources, are provided for each Ecological System in Appendix B. Species with a coefficient of conservatism value ≤ 3 were also reviewed as potential native "increasers". However, the mere presence of these species is not enough to indicate that they are acting as increasers. Instead, their proportion relative to what is expected triggers that designation. This concept tends to work well in occurrences exposed to conspicuous stressors such as livestock grazing where increasers tend to dominate or become monocultures (e.g. *Ericameria nauseosa* in shrub-steppe habitats, *Lupinus* species in montane grasslands). Because presence/absence is not enough to score this submetric it can be a difficult measure for many users. If that is the case, you can ignore this submetric and make a note in the Veg 3 metric comment section explaining your reasoning.

Native Decreaser Species: Native species that decline rapidly from stressors (i.e. "conservative species"). Examples, along with sources, are provided for each Ecological System in Appendix B. Species with a coefficient of conservatism value ≥ 7 were also reviewed as potential native "decreasers" (see Washington Floristic Quality databases for eastern and western Washington (http://www.dnr.wa.gov/NHP-FQA).

Table 7. Cover Classes.

Cover Class	Range	Midpoint
1	Trace	0.25%
2	0-1%	0.5%
3	1-2%	1.5%
4	2-5%	3.5%
5	5-10%	7.5%
6	10-25%	17.5%
7	25-50%	37.5%
8	50-75%	62.5%
9	75-95%	85%
10	> 95%	97.5

3.5 EIA Metric Ratings and Scores

For each metric, an “A”, “B”, “C”, or “D” rank is selected. These ranks are informed by the following:

- Rating criteria descriptions contained within this manual
- Ecological Systems Guide (Rocchio & Crawford, 2015)
- *Identifying Old Trees and Forests in Eastern Washington* (Van Pelt, 2008) (http://file.dnr.wa.gov/publications/lm_hcp_east_old_growth_hires_part01.pdf)
- *Identifying Mature and Old Forests in Western Washington* (Van Pelt, 2007) (http://file.dnr.wa.gov/publications/lm_hcp_west_oldgrowth_guide_full_lowres.pdf)
- Relevant GIS data other data sources.

Field crews are encouraged to assign a single rating, but a range rank may be used (i.e., “AB”, “BC”, or “CD”) in cases of uncertainty or in metrics in early stages of field-testing. The range rank does not indicate an intermediate rank, but that the metric may be one or the other. We also discourage the use of intermediate or plus/minus ranks (e.g., “A-“, “B-“, or “C-“) at the metric level, as it may generate a sense of precision that is not present in a rapid assessment such as this. Some metrics do allow intermediate ranks and provide metric scoring language for them--these metrics are the exception. For example, when rating the “Native Plant Species Cover” metric, we find it helpful to distinguish “A” scores from “A-“ scores. Metric ratings should be entered on the EIA field form. Associated scores for each rating (Table 8) are then used for roll-up calculations (Section 4.0). Users are encouraged to take notes in the comments field associated with each metric. These comments can prove invaluable in communicating the reasons underlying any given rating.

Table 8. Metric Rating and Points. Occasionally, metric ratings are further subdivided (e.g. “B” (3.0) and “B-“ (2.5), or “C” (2.0) and “C-“ (1.5)).

Metric Rating	Points
A	4.0
B	3.0
C	2.0
D	1.0

When multiple assessment points are used, the submetric and overall metric ratings are simply the average of all of the assessment point ratings. It does not matter if you average across each submetric and then average the submetrics together, or average across each assessment point and then average the assessment points together. In either direction, the overall metric rating for the AA will remain the same. Note that for large AAs, Landscape Context, Edge, and Size ratings are scored for the entire assessment area, not individual assessment points.

3.6 LANDSCAPE CONTEXT METRICS

LAN1 Contiguous Natural Land Cover

Definition: A measure of connectivity using the percent of natural habitat directly connected to the AA. **Note that** for large AAs (> 50 ha), this metric is assessed at the scale of the entire AA, not for individual assessment points within the AA.

Background: This metric serves as a proxy measure of the capacity for natural disturbances to occur on the landscape (e.g. fire). This metric also addresses the broader connectivity of the natural land cover by measuring the natural habitat that is directly contiguous to the AA. However, not all organisms and processes require directly contiguous habitat, and organisms perceive "connectivity" differently, so this metric may underestimate contiguous habitat for some organisms. The importance of this metric is assumed to differ between small-patch and large-patch/matrix ecosystem targets. As such, the spatial pattern of the ecosystem target determines the weight of this metric for roll-up and EIA score calculations.

Apply To: All EIA modules and AA sizes. For large AAs, this is scored for the entire assessment area, not individual assessment points.

Measurement Protocol: Identify the percent of natural land cover within 500 m that is directly connected to the AA and then score the metric using Table 10. We recommend using NatureServe's Ecological Systems map (http://www.natureserve.org/conservation-tools/terrestrial-ecological-systems-united-states) as a foundation for measurement of natural land cover. The GIS layer can be downloaded here: https://fortress.wa.gov/dnr/adminsa/DataWeb/dmmatrix.html#Natural_Heritage. The National Land Cover database (http://www.mrlc.gov/nlcd2011.php) may also be used. Ground-truthing or comparison with recent aerial photography is advised, since remotely sensed data sources may misinterpret some land cover types. Well-traveled dirt roads and major fire breaks divide occurrences, but vegetated two-track roads, hiking trails, hayfields, low fences and small ditches may be included (Table 9 provides guidance for distinguishing natural from non-natural land cover). Any cover type that "breaks" natural cover must be greater than five meters wide (or contribute to a break that is at least that wide). See Figure 8 for an example.

Table 9. Guidelines for Identifying Natural Land Cover.

Examples of Cover Types Included in Natural Land Cover	Examples of Cover Types Excluded from Natural Land Cover	Examples of Cover Types Crossing and Breaking Natural Edges[4]

Natural or ruderal[1] plant communities; open water[2] vegetated levees; old fields; naturally vegetated rights-of-way; rough meadows; natural swales and ditches; native or naturalized rangeland and non-intensive plantations[3]	Parking lots; commercial and private developments; roads (all types), intensive agriculture; intensive plantations; orchards; vineyards; dry-land farming areas; railroads; planted pastures (e.g., from low intensity to high intensity horse paddock, feedlot, or turkey ranch); planted hayfields; lawns; sports fields; traditional golf courses; Conservation Reserve Program pastures	Bike trails; horse trails; dirt, gravel or paved roads; residential areas; bridges; culverts; railroads; sound walls; fences that interfere with movements of species and processes that are critical to the overall functioning of the occurrence

[1]Ruderal plant communities: Plant communities dominated or codominated by nonnative species OR communities dominated by native species, but resulting from past human stressors and possessing no natural analog. For example, areas previously plowed may be revegetated by native vegetation, but composition may be unlike other plant communities. Novel ecosystems also fall into this category.

[2]Open Water: Some protocols exclude open water (such as lakes, large rivers, or lagoons) from natural land cover because the water quality or water disturbance regime (natural waves vs. boat traffic waves) may or may not be in good condition. Here we include open water. If desired, the condition of the open water can be assessed using the Condition of Natural Edge metric (EDG3).

[3]Plantations: Logged and replanted areas in which the overstory is allowed to mature and may regain some native component, and in which the understory of saplings, shrubs, and herbs are native or naturalized species and not strongly manipulated (i.e., they are not “row-crop tree plantings” with little to no vegetation in the understory, typical of intensive plantations).

[4]Cover Types Crossing and Breaking Natural Edges: These cover types are added to cover types excluded from natural land cover so that, collectively, they may contribute to a 5 m break in natural land cover.

Table 10. Contiguous Natural Land Cover Metric Rating.

Metric Rating	Percent Continuous Natural Land Cover
EXCELLENT (A)	**Intact:** Embedded in 90-100% natural habitat around AA. Connectivity is expected to be high; fire regime is relatively unimpeded by fragmentation; remaining natural habitat is in good condition (low modification); and a mosaic with gradients.
GOOD (B)	**Variegated:** Embedded in 60-90% natural habitat. Connectivity is generally high, but lower for species sensitive to habitat modification; remaining natural habitat with low to high modification and a mosaic that may have both gradients and abrupt boundaries.
FAIR (C)	**Fragmented**: Embedded in 20-60% natural habitat. Connectivity is generally low, but varies with mobility of species and arrangement on landscape; remaining natural habitat with low to high modifications and gradients shortened.
POOR (D)	**Relict**: Embedded in < 20% natural habitat. Connectivity is essentially absent; remaining natural habitat generally highly modified and generally uniform.

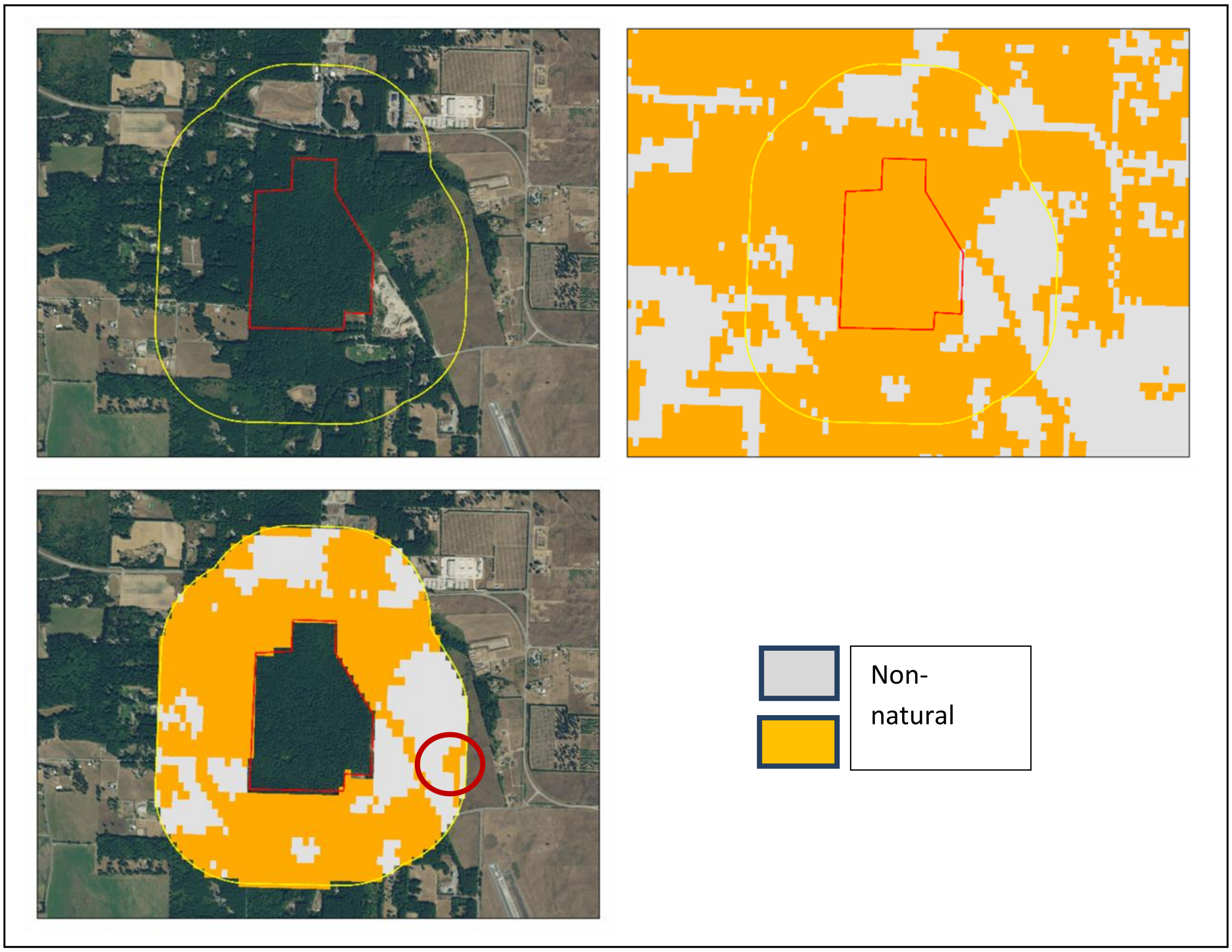

Figure 8. Contiguous Natural Land Cover Evaluation Based on Percent Natural Vegetation Directly Connected to AA. TOP LEFT: Aerial imagery showing the Assessment Area (red line) and 500 m landscape context envelope (yellow line). TOP RIGHT: The categories in NatureServe's Ecological Systems map have been cross-walked to land use categories in the GIS download available on the WNHP website. These land use categories were then lumped as 'natural' and 'non-natural' in the COVER_TYPE field. BOTTOM: After clipping the Ecological Systems raster and making adjustments based on ground-truthing and aerial photography interpretation, the percent Contiguous Natural Land Cover is calculated. This can be done using summary statistics in ArcGIS or by exporting the raster table to Excel and calculating there. In this example, 63.3% of the area counts as Contiguous Natural Land Cover (Table 11), a "B" rating (Table 10). Note that the portion of natural land cover in the southeast corner is not contiguous with the assessment area and was thus excluded from the total.

Table 11. Demonstration of Contiguous Natural Land Cover Scoring.

Count (pixels)	Area (m^2)	Ecological System	Natural / Non-Natural	Total Area (m^2)
12	360	North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland	Natural	46,050
1284	38520	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	Natural	

148	4440	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest	Natural	
53	1590	North Pacific Lowland Riparian Forest and Shrubland	Natural	
38	1140	Temperate Pacific Freshwater Emergent Marsh	Natural	
100	3000	Cultivated Cropland	Non-Natural	26,670
34	1020	Pasture/Hay	Non-Natural	
394	11820	Harvested Forest - Grass/Forb Regeneration	Non-Natural	
32	960	Harvested Forest-Shrub Regeneration	Non-Natural	
11	330	Quarries, Mines, Gravel Pits and Oil Wells	Non-Natural	
110	3300	Developed, Open Space	Non-Natural	
153	4590	Developed, Low Intensity	Non-Natural	
55	1650	Developed, High Intensity	Non-Natural	
			% NATURAL	63.3%
			CONTIGUOUS NATURAL LAND COVER RATING	B

LAN2 Land Use Index (0-500 m)

Definition: This metric measures the intensity of human-dominated land uses in the surrounding landscape (0-500 m). Note that for large AAs this metric is assessed at the scale of the entire AA, not for individual assessment points within the AA.

Background: This metric is one aspect of landscape context. It is based on Hauer et al. (2002), Mack (2006), and Comer and Faber-Langendoen (2013). The importance of this metric is assumed to differ between small-patch and large-patch/matrix ecosystem targets. As such, the spatial pattern of the ecosystem target determines the weight of this metric for roll-up and EIA score calculations.

Apply To: All EIA modules and AA sizes. For large AAs, this is scored for the entire assessment area, not individual assessment points.

Measurement Protocol: This metric assesses the percentage of the surrounding landscape subjected to different land uses. Ideally, both field data and remote sensing tools (e.g. aerial photography or satellite imagery) are used to identify an accurate percentage of each land use within the 500m landscape envelope. For large AAs, remotely sensed data may be used on their own. To calculate a Total Land Use Score, estimate the percentage of each land use category and then plug the corresponding coefficient (found on the field form and Table 12) into the following equation:

Sub-land use score = $\sum$ LU x PC/100

LU = Land Use weight for Land Use Category

PC = % of adjacent area in Land Use Category

That score can then be rated using Table 15. See Figure 9, Table 13, and Table 14 for an example.

Table 12. Land Use Index Table.

Worksheet : Land Use Categories	Weight	% Area (0 to 1.0)	Score
Paved roads / parking lots	0		
Domestic, commercial, or publicly developed buildings and facilities (non-vegetated)	0		
Gravel pit / quarry / open pit / strip mining	0		
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive, logging roads)	1		
Agriculture: tilled crop production	2		
Intensively developed vegetation (golf courses, lawns, etc.)	2		
Vegetation conversion (chaining, cabling, roto-chopping, clearcut)	3		
Agriculture: permanent crop (vineyard, orchard, nursery, hayed pasture, etc.)	4		
Intense recreation (ATV use / camping / popular fishing spot, etc.)	4		
Military training areas (armor, mechanized)	4		
Heavy grazing by livestock on pastures or native rangeland	4		
Heavy logging or tree removal (50-75% of trees > 30 cm DBH removed)	5		
Commercial tree plantations / holiday tree farms	5		
Recent old fields and other disturbed fallow lands dominated by ruderal and exotic species	5		
Dam sites and flood disturbed shorelines around water storage reservoirs and motorized boating	5		
Moderate grazing of native grassland	6		
Moderate recreation (high-use trail)	7		
Mature old fields and other fallow lands with natural composition	7		
Selective logging or tree removal (< 50% of trees > 30 cm DBH removed)	8		
Light grazing or haying of native rangeland	9		
Light recreation (low-use trail)	9		
Natural area / land managed for native vegetation	10		
A = $\geq$9.5, **B** = 8.0-9.4, **C** = 4.0-7.9, **D** = < 4.0 Total Land Use Index			

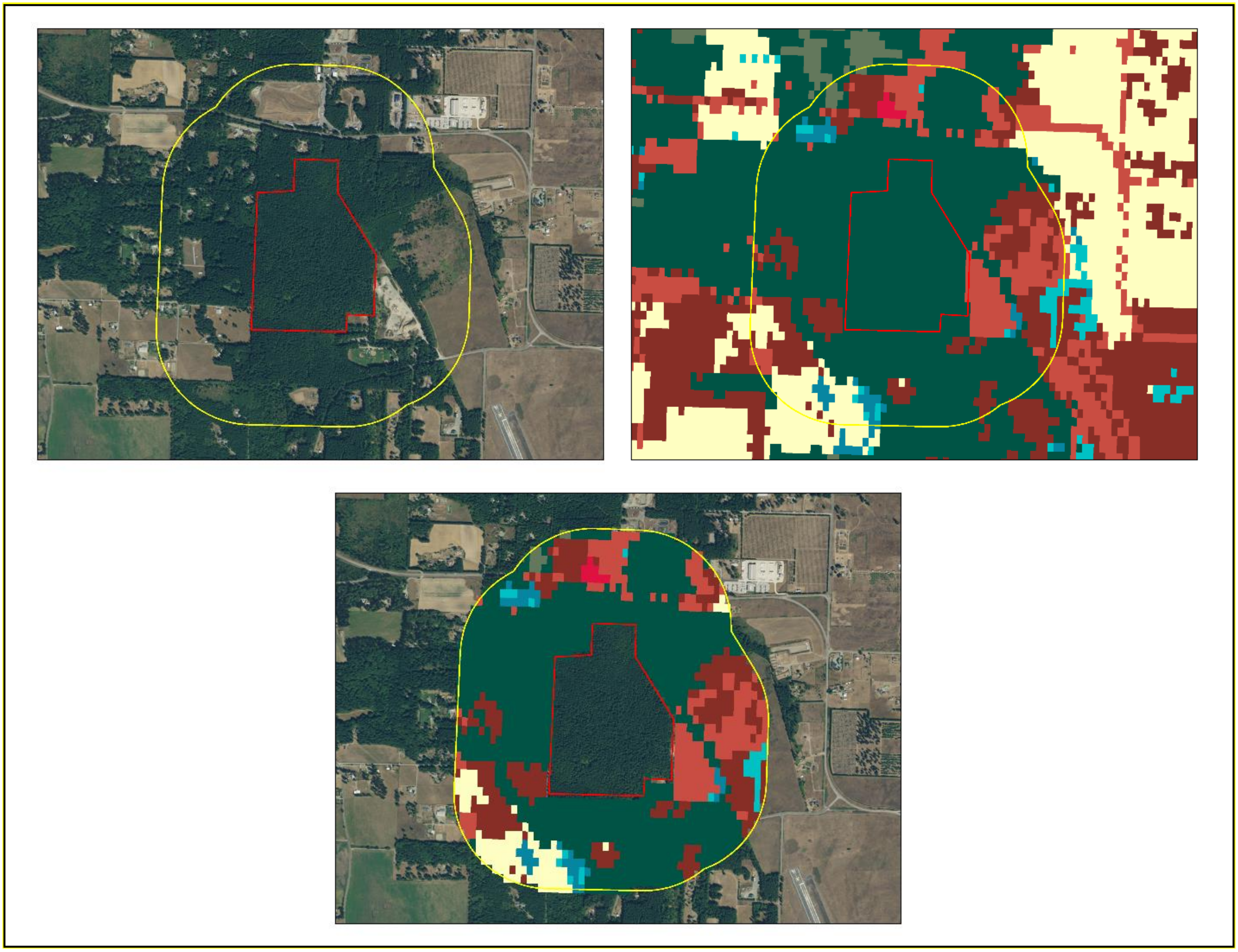

Figure 9. Demonstration of Using Remote Sensing Methods for Scoring the Land Use Index metric. TOP LEFT: Aerial imagery showing the Assessment Area (red line) and 500 m landscape context envelope. TOP RIGHT: NatureServe's Ecological Systems map shows various land uses which have been crosswalked to land use categories (Table 13) in the LAND_USE_CAT field in the GIS download available on the WNHP website. BOTTOM: After clipping, the percent area of each land use is recorded and multiplied by the land use's weight (Table 14). Be sure to look at the imagery closely for any discrepancies (recent disturbance, poor model interpretation of cover, etc.) and incorporate on-the-ground observations. The Land Use Index metric rating in this example was a "C".

Table 13. Demonstration of Using Land Use Coefficients to Assess the Land Use Index Metric.

Count (pixels)	Area (m^2)	Ecological System	Land Use Category
103	3090	North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland	Natural area / land managed for native vegetation
2358	70740	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	
610	18300	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest	
74	2220	North Pacific Lowland Riparian Forest and Shrubland	

Count (pixels)	Area (m^2)	Ecological System	Land Use Category
2	60	North Pacific Shrub Swamp	
92	2760	Temperate Pacific Freshwater Emergent Marsh	
202	6060	Cultivated Cropland	Agriculture: tilled crop production
507	15210	Pasture/Hay	Agriculture: permanent crop (vineyard, orchard, nursery, hayed pasture, etc.)
715	21450	Harvested Forest - Grass/Forb Regeneration	
63	1890	Harvested Forest-Shrub Regeneration	Heavy logging or tree removal (50-75% of trees > 30 cm DBH removed)
11	330	Quarries, Mines, Gravel Pits and Oil Wells	Gravel pit / quarry / open pit / strip mining
173	5190	Developed, Open Space	Recent old fields and other disturbed fallow lands dominated by ruderal and exotic species
336	10080	Developed, Low Intensity	Domestic, commercial, or publicly developed buildings and facilities (non-vegetated)
74	2220	Developed, High Intensity	

Table 14. Demonstration of final Land Use Index Metric Score.

Land Use Category	Weight	% of Area (by Land Use)	Score
Natural area / land managed for native vegetation	10	60.88%	6.1
Agriculture: tilled crop production	2	3.80%	0.1
Agriculture: permanent crop (vineyard, orchard, nursery, hayed pasture, etc.)	4	22.97%	0.9
Heavy logging or tree removal (50-75% of trees > 30 cm DBH removed)	5	1.18%	0.1
Gravel pit / quarry / open pit / strip mining	0	0.21%	0.0
Recent old fields and other disturbed fallow lands dominated by ruderal and exotic species	5	3.25%	0.2
Domestic, commercial, or publicly developed buildings and facilities (non-vegetated)	0	7.71%	0.0
		TOTAL	7.3
		LAND USE INDEX METRIC RATING	C

Table 15. Metric Rating for Land Use Index.

Metric Rating	*Land Use Index Variant: Small Patch*
EXCELLENT (A)	Average Land Use Score = 9.5-10
GOOD (B)	Average Land Use Score = 8.0-9.4
FAIR (C)	Average Land Use Score = 4.0-7.9
POOR (D)	Average Land Use Score = < 4.0

3.7 EDGE

For rapid assessments, we assess a 100 m zone extending beyond the boundary of the assessment area, using up to three metrics (dependent on patch size): (EDG1) Perimeter with Natural Edge, (EDG2) Width of Natural Edge, and (EDG3) Condition of Natural Edge. These are synonymous with the Buffer metrics in the wetland and riparian EIA (Rocchio et al., 2016). EDG3 requires a field visit in combination with aerial photography. Only the *natural* land cover surrounding the assessment area is assessed for these metrics. Note that Land Use Index (LAN2) includes an evaluation of all land uses within the edge zone (0–100 m), so it addresses the condition of the non-natural parts surrounding the assessment area.

EDG1 Perimeter with Natural Edge

Definition: Percentage of the perimeter of the assessment area that has a natural edge (borders natural land cover).

Background: This metric is similar to the BUF1 “Perimeter with Natural Buffer” metric used in wetland EIAs, with simple nomenclatural changes made to adapt it to upland settings. “Edge effects”—or the influence of one patch on a neighboring patch (Turner et al., 2001)—are major drivers of change in fragmented landscapes. Natural ecosystems experience significant changes in air temperature, light intensity, soil moisture, wind throw, and other key drivers when they border unnatural areas. These impacts are widespread and persistent and may originate from even small disturbances in the surrounding area (Bell et al., In Press). Additionally, unnatural edges are associated with altered fire regimes and increased colonization by exotic plants. We assess key aspects of the edge within a 100 m zone, but add a surrounding landscape assessment that extends to 500 m from the AA boundary (see metrics LAN1 and LAN2 above).

We only include natural habitats as part of the edge, as these habitats are most typical of the historical condition. The definition of natural habitats corresponds with that of the USNVC (i.e., both native habitat and ruderal habitats, including naturally invaded or degraded native habitats), thereby permitting a direct application of NVC and Ecological System maps to the evaluation. This definition is also consistent with the use of natural habitats for other EIA metrics.

Apply To: All EIA modules and AA sizes. For large AAs, this is scored for the entire assessment area, not individual assessment points.

Measurement Protocol: Estimate the length of the AA perimeter that borders natural land cover. This can be done using remotely sensed data and/or field-based observations. If remotely sensed data are used, field verification is recommended. Use a 10 m minimum edge width. Use Table 9 to help guide your assessment of natural v. unnatural and rate the metric using Table 16.

Table 16. Edge Perimeter Rating.

Metric Rating	Percent of AA with Natural Edge
EXCELLENT (A)	Natural buffer/edge is 100% of AA perimeter
GOOD (B)	Natural buffer/edge is 75-99% of AA perimeter
FAIR (C)	Natural buffer/edge is 25-75% of AA perimeter
POOR (D)	Natural buffer/edge is < 25% of AA perimeter

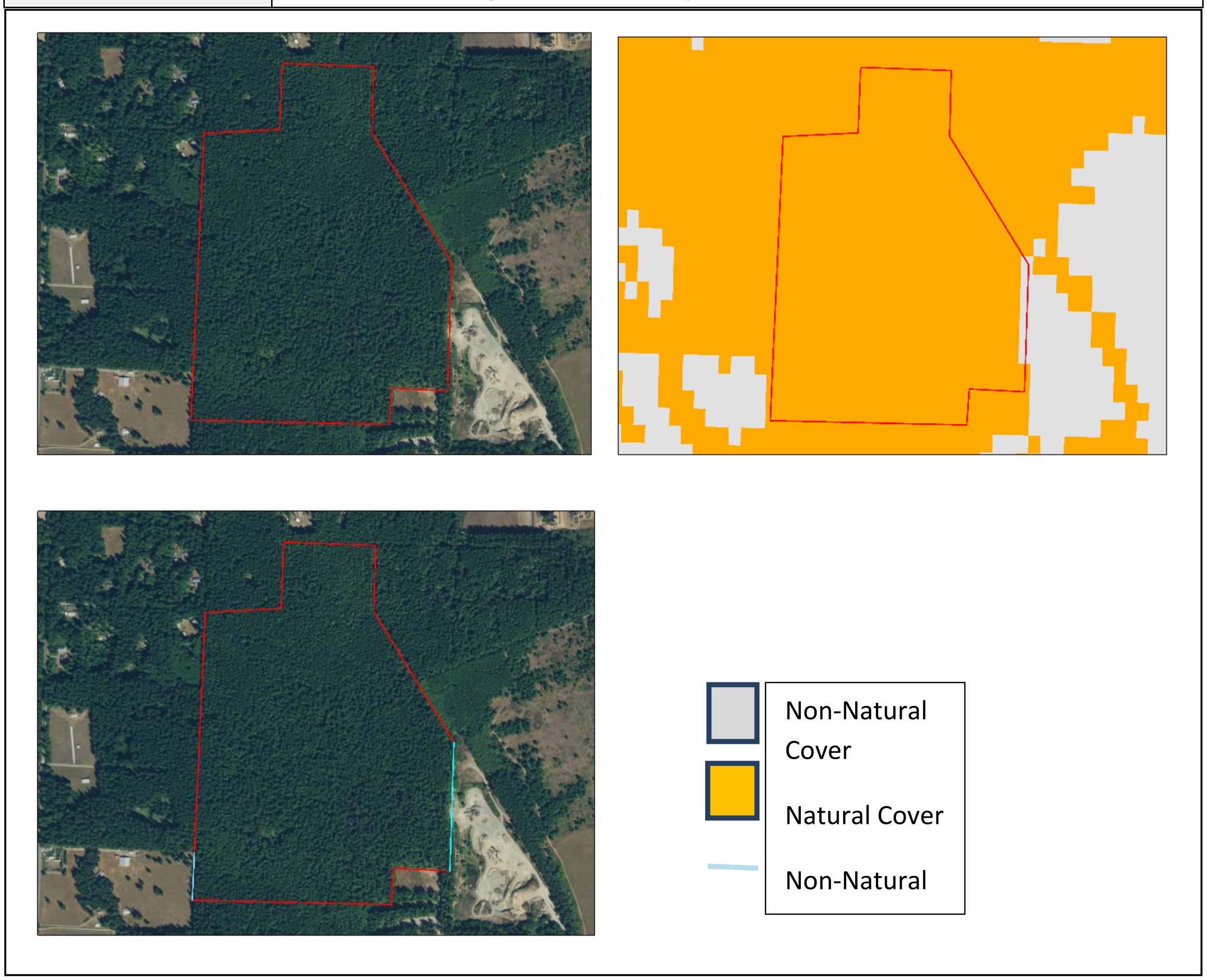

Figure 10. Edge Perimeter Example. TOP LEFT: Aerial imagery showing the assessment area (red line). TOP RIGHT: NatureServe's Ecological Systems map shows location of natural and non-natural land cover types. In this case, it comes close to accurately representing those edges that border non-natural land cover types, but the variations in resolution between the raster and the digitized boundary make it impractical to simply overlay them for this exercise. Aerial photography or ground truthing can compensate for this discrepancy. BOTTOM LEFT: Aerial imagery shows

portions of the edge without a natural cover (blue lines). The total AA perimeter length is 2,910 m and the non-natural portion totals 423 m, meaning the edge is 85% natural (a "B" rating).

EDG2 Width of Natural Edge

Definition: A measure of the average width of the natural edge, extending from the boundary of the Assessment Area to a maximum distance of 100 m.

Background: This metric is similar to the BUF2 "Width of Natural Buffer" metric used in wetland EIAs, with simple nomenclatural changes made to adapt it to upland settings. "Edge effects"—or the influence of one patch type on a neighboring patch (Turner et al., 2001)—are major drivers of change in fragmented landscapes. Natural ecosystems experience significant changes in air temperature, light intensity, soil moisture, wind throw, and other key drivers when they border unnatural areas. These impacts are widespread and persistent and may originate from even small disturbances in the surrounding area (Bell et al., In Press). Additionally, unnatural edges are associated with altered fire regimes and increased colonization by exotic plants. We assess key aspects of the edge within a 100 m zone surrounding the AA.

We only include natural habitats as part of the edge, as these habitats are most typical of the historical condition. The definition of natural habitats corresponds with that of the USNVC (i.e., both native habitat and ruderal habitats, including naturally invaded or degraded native habitats), thereby permitting a direct application of NVC and system maps to the evaluation. This definition is also consistent with the use of natural habitats for other EIA metrics.

Apply To: All EIA modules and AA sizes. For large AAs, this is scored for the entire assessment area, not individual assessment points.

Measurement Protocol: This metric is applied using one of two approaches: (1) Point-based or Simple Polygon AAs or (2) complex polygon AAs:

<u>Point-based or simple polygon shapes</u>: Metric is adapted from Collins et al. (2006) and Collins & Fennessy (2011).

1. Using the most recent aerial imagery, draw eight straight lines radiating out from the approximate center of the AA in eight cardinal directions (N, NE, E, SE, S, SW, W, NW), each extending 100 m beyond the boundary of the AA (Figure 11).
2. Measure the length of each line from the edge of the AA perimeter to the outer extent of the natural edge and record on data form (see example in Table 18).
3. If desired, use the slope multipliers in Table 20 to adjust the rating of upslope edge widths. Multiply by the edge rating values to get a new set of rating values. Slope can be estimated in the field or using imagery.
4. Assign a metric score based on the average edge width (Table 17).

Table 17. Edge Width Rating.

Metric Ratings	Average Natural Edge Width (m)
EXCELLENT (A)	≥ 100 m, adjusted for slope.
GOOD (B)	75-99 m, adjusted for slope.
FAIR (C)	25-75 m, adjusted for slope.
POOR (D)	< 25 m, adjusted for slope.

Table 18. Edge Width Calculation (Simple Polygon Example).

Line	Edge Width (m) (max = 100 m)
1	100
2	100
3	0
4	40
5	100
6	0
7	100
8	68
Average Edge Width (m)	**63.5**

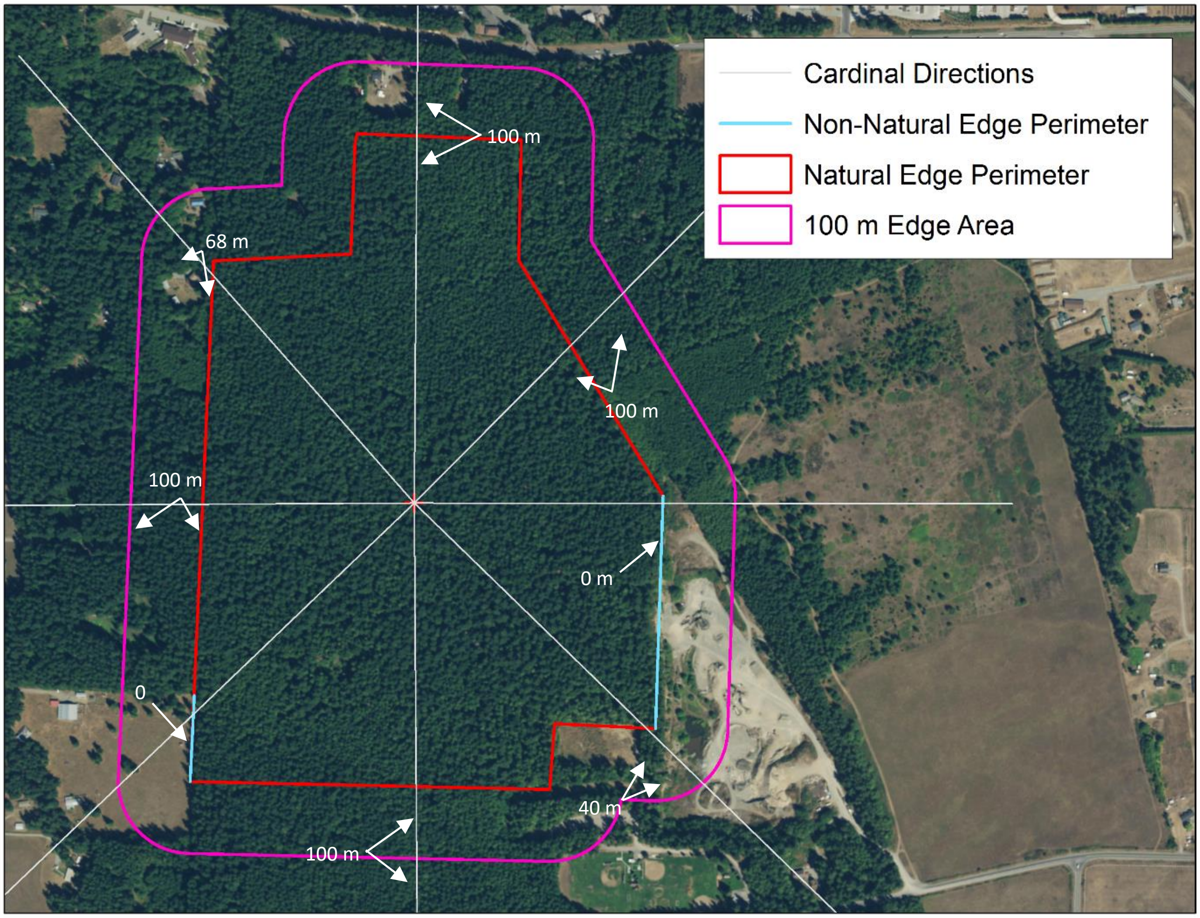

Figure 11. Edge Width Calculation (Point-Based or Simple Polygons). The width of natural edge is measured by calculating the distance between the boundary of the AA and the 100 m buffered line along each of the eight white lines and averaging them. In this example the calculation for average edge width is (moving clockwise): (100+100+0+40+100+0+100+68)/8=63.5 m (Table 18). That translates to a "C" rating (Table 17).

Complex polygon shapes

1. For AA polygons lacking a centroid from which eight spokes could reasonably radiate from, draw a line as near to the center of the AA polygon's long axis as possible where the line follows the broad shape of the polygon, avoiding finer level twists and turns (Figure 12).
2. Once you have determined the length of the line along the AA's long axis, divide the line by five, creating four equally spaced points along the axis. At each of the four points, draw a line perpendicular to the axis such that it extends out 100 m beyond each side of the AA's perimeter. For some arching AA's that close back in on themselves, see guidance below to address situations that may arise from interior spokes (i.e., spokes radiating away from the AA's interior arch).
    a. When two spokes cross one another, eliminate the spoke with the longer natural edge width and locate a new spoke at the more northerly end of the AA's long axis; extend the axis 100 m beyond the AA perimeter to form a new spoke.

   b. When a spoke heads back into the AA in less than 100 m, eliminate the spoke and locate a new spoke at the more northerly end of the AA's long axis.

   c. If two spokes need to be relocated, use both ends of the AA's long axis.

3. For spokes radiating out from the AA's exterior arch, if the spoke begins to cross a smaller lobe of the system in less than 100 m, allow the spoke to continue in the same direction through the lobe and measure edge width where the spoke can be extended beyond the lobe for 100 m (Figure 12).
4. For each of the eight spokes, determine the natural edge width from the AA's boundary until either an unnatural land cover is encountered or 100 m of contiguous natural buffer width is measured, whichever comes first.
5. Determine the average width of the edge (Table 19).
6. If desired, use the slope multipliers in
7. Table 20 to adjust the rating of upslope edge widths. Multiply by the edge rating values to get a new set of rating values. Slope can be estimated in the field or using imagery.
8. Assign a metric score based on the average edge width (Table 17).

Table 19. Edge Width Calculation (Complex Polygon Example).

Spoke or Line	Edge Width (out to a maximum of 100 m)
Single west terminal spoke	10
West exterior spoke	18
West interior spoke	100
West-central exterior spoke	0
West-central interior spoke	0
East-central exterior spoke	0
East-central interior spoke	Not Used
South-east exterior spoke	7
South-east interior spoke	10
Average Edge Width (m)	**18**

Table 20. Slope Modifiers for Edge Width.

Slope Gradient	Additional Edge Width Multiplier
5-14%	1.3
15-40%	1.4
> 40%	1.5

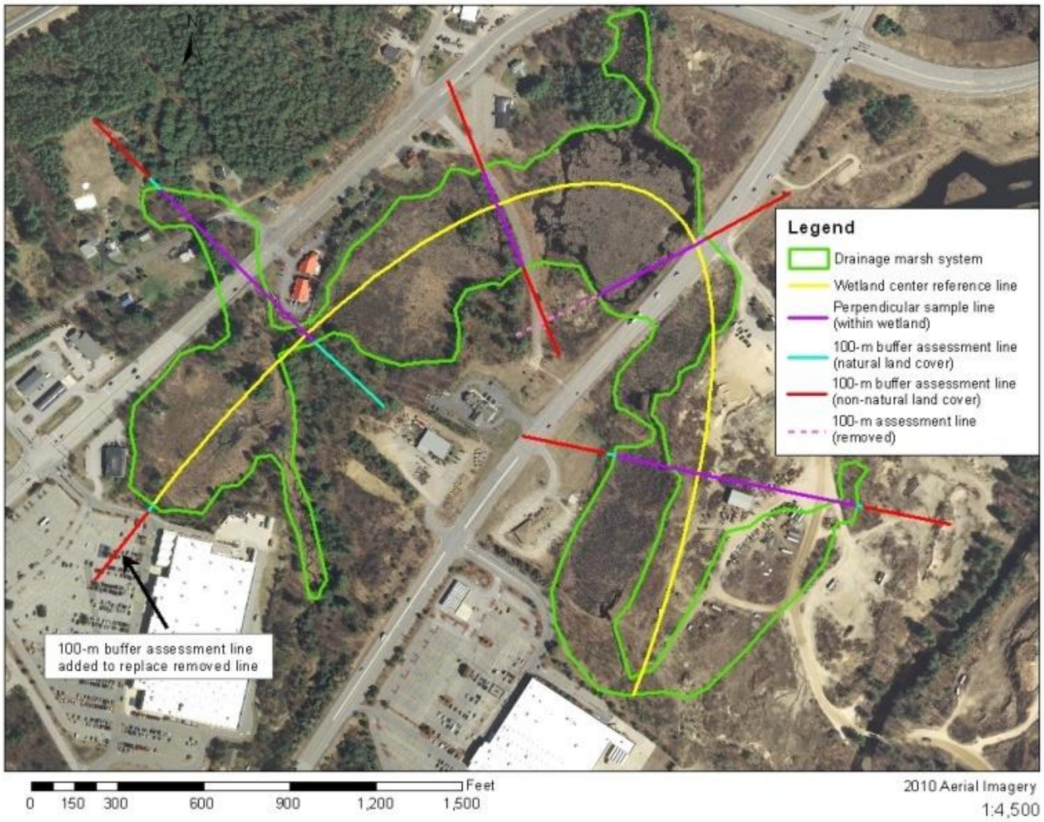

Figure 12. Edge Width Calculation (Complex Polygon Example). The eight spokes or lines are assessed for the edge width. For example, the single west terminal spoke has a 10 m wide edge. Once measured, average the eight edge widths to calculate the average width of the edge. Figure by Bill Nichols, New Hampshire Natural Heritage Program (from a wetland EIA example).

EDG3 Condition of Natural Edge

Definition: A measure of the biotic and abiotic condition of the natural edge, extending from the boundary of the Assessment Area.

Background: This metric is similar to the BUF3 "Condition of Natural Buffer" metric used in wetland EIAs, with simple nomenclatural changes made to adapt it to upland settings. "Edge effects"—or the influence of one patch type on a neighboring patch (Turner et al., 2001)—are major drivers of change in fragmented landscapes. Natural ecosystems experience significant changes in air temperature, light intensity, soil moisture, wind throw, and other key drivers when they border unnatural areas. These impacts are widespread and persistent and may originate from even small disturbances in the surrounding area (Bell et al., In Press). Additionally, unnatural edges are associated with altered fire regimes and increased colonization by exotic plants. We assess key aspects of the edge within a 100 m zone.

Apply To: Small AAs of all EIA modules.

Measurement Protocol: Estimate the overall biotic and abiotic condition within that part of the perimeter that has a natural edge. That is, if perimeter with natural edge is only 30%, assess condition within that 30%. Condition is based on percent cover of native vegetation, disruption to soils, signs of reduced water quality, amount of trash or refuse, various land uses, and intensity of human visitation and recreation. The evaluation can be made by scanning an aerial photograph in the office, followed by ground truthing, as needed. Ground truthing could be made systematic by following the eight lines used to assess edge width (EDG2), scoring each separately and then averaging for the overall metric score.

Table 21. Condition of Natural Edge Rating.

Metric Ratings	Natural Edge Condition
EXCELLENT (A)	Buffer/edge is characterized by abundant (> 95%) cover of native vegetation, with intact soils, no evidence of loss in water quality, and little or no trash or refuse.
GOOD (B)	Buffer/edge is characterized by substantial (75 – 95%) cover of native vegetation, intact or moderately disrupted soils, minor evidence of loss in water quality, moderate or lesser amounts of trash or refuse, and minor intensity of human visitation or recreation.
FAIR (C)	Buffer/edge is characterized by low (25 – 75%) cover of native vegetation, barren ground and moderate to highly compacted or otherwise disrupted soils, strong evidence of loss in water quality, with moderate to strong or greater amounts of trash or refuse, and moderate or greater intensity of human visitation or recreation.
POOR (D)	Buffer/edge is characterized by very low (< 25%) cover of native plants, dominant (> 75%) cover of nonnative plants, extensive barren ground and highly compacted or otherwise disrupted soils, moderate - great amounts of trash, moderate or greater intensity of human visitation or recreation, OR no natural edge at all.

3.8 VEGETATION

Vegetation varies greatly across the diversity of Washington's Ecological Systems. For that reason, some vegetation metrics have different variants based on the EIA module (i.e. grouping of Ecological Systems; Table 22).

Table 22. Metric Variants for Vegetation by EIA Module.

	VEGETATION					
Metric Variant by EIA Module	**VEG1. Native Plant Species Cover**	**VEG2. Invasive Nonnative Plant Species Cover***	**VEG3. Native Plant Species Composition***	**VEG4. Vegetation Structure ****	**VEG5. Woody Regeneration (Optional) ****	**VEG6. Coarse Woody Debris (Optional) ****

Dry Forests & Woodlands	v1	v1	v1	v7	v2	v3
Mesic / Hypermaritime Forests				v8	v3	v4
Shrublands				v9	n/a	n/a
Shrub-Steppe				v10	n/a	n/a
Grasslands / Meadows				v11	n/a	v5
Bedrock / Cliffs				v12	n/a	n/a

* VEG2 and VEG3 metrics are based on specific indicators associated with individual Ecological Systems.

**Metric variants not listed here are wetland variants (see Rocchio et al., 2016).

VEG1 Native Plant Species Cover

Definition: A measure of the relative percent cover of all plant species in the AA that are native to the region. The metric is typically calculated by estimating total absolute cover of all vegetation within each of the two major strata groups (tree and shrub/sapling/herbaceous) and then expressing the total native species cover as a percentage of the total stratum cover. The stratum with the lowest percentage of native cover is used as the basis for the score.

Background: This metric was developed by NatureServe's Ecological Integrity Assessment Working Group (Faber-Langendoen et al. 2008). Nonvascular species are not included—desirable as that may be in some occurrences—because of difficult species identification and interpretation of what those species indicate about ecological integrity.

Apply To: All EIA modules and AA sizes.

Measurement Protocol: This metric evaluates the relative percent cover of native species compared to all species (native and nonnative) for each of the three major strata (Native cover divided by / (Native + Nonnative cover) * 100). The protocol consists of a visual estimation of native vs. nonnative species cover using midpoints of cover classes (on the field form). The field survey method may be either (1) a Site Survey (semi-quantitative) method, in which the observers walk the entire occurrence (or assessment area within the occurrence) and make notes on native and total species cover, or (2) Quantitative Plot Data, where a fixed area is surveyed, using either plots or transects. The plot or transect is typically a "rapid" plot, but a single intensive plot can also be taken. First, using cover class values in Table 7, estimate the total cover of vegetation by summing species cover across strata and growth forms (e.g., cover of tree canopy/subcanopy and shrub/ herb strata, combining growth forms within the same strata). The total may easily exceed 100%. Next, estimate the total cover of nonnative species in each and subtract those values from the total vegetation cover values to get the total native cover for each stratum. Divide the total native cover by the total vegetation cover and multiply by 100. This method can be used when all species, or only dominant species, are listed. Assign the score in Table 23 based on the stratum with the *lowest* percent of native plant species cover. If plot data are used for this metric, it is important that the plot is representative of the larger system being assessed. In patchy ecosystems or large AAs, more than one plot may be desirable.

Table 23. Metric Ratings for Native Plant Cover. If scoring strata groups, choose lowest score between groups.

Rank	*Submetric: Tree Strata*	*Submetric: Shrub/Herb Strata*	Metric Score
Excellent (A) > 99% relative cover of native vascular plant species overall, OR whichever is lower in the key layer (either the tree stratum or shrub/herb strata)			
Very Good (A-) 95-99% relative cover of native vascular plant species overall, OR whichever is lower in the key layer (either the tree stratum or shrub/herb strata)			
Good (B) 85-94% relative cover of native vascular plant species overall, OR whichever is lower in the key layer (either the tree stratum or shrub/herb strata)			
Fair (C) 60-84% relative cover of native vascular plant species overall, OR whichever is lower in the key layer (either the tree stratum or shrub/herb strata)			
Poor (D) < 60% relative cover of native vascular plant species overall, OR whichever is lower in the key layer (either the tree stratum or shrub/herb strata)			

VEG2 Invasive Nonnative Plant Species Cover

Definition: The absolute percent cover of nonnative species that are considered invasive to the ecosystem being evaluated. Generally, an invasive species is defined as "*a species that is nonnative to the ecosystem under consideration and whose introduction causes or is likely to cause environmental harm*…" (Clinton, 1999; Richardson et al., 2000), thus potentially including species native to a region, but invasive to a particular ecosystem in that region. However, here we treat those "native invasives" as "native increasers" under the Native Species Composition metric. Nonvascular species are not included—desirable as that may be in some occurrences—because of difficult species identification and interpretation of what those species indicate about ecological integrity.

Background: This metric is a counterpart to "Relative Native Plant Species Cover," but only assesses invasive nonnatives, not all nonnatives. Even here, judgment may be required. For example, some species are native to a small part of a region—or have mixed genotypes of both native and nonnative forms—and are widely invasive (e.g., *Phragmites*). Field crews must be provided with a definitive list of what is considered a nonnative invasive in their project area.

The definition of invasive used here is refers to those nonnative plants that have major perceived impacts on ecosystem condition, what Richardson et al. (2000) refer to as "transformers". They distinguish invasives (naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants and thus have the potential to spread over a considerable area) from "transformers" (A subset of invasive plants that change the character, condition, form, or nature of ecosystems over a substantial area relative to the extent of that ecosystem). Although our definition is essentially equal to that of "transformers" in that we are concerned with those naturalized plants that cause ecological impacts, we retain the term "invasive" as the more widely used term. Our use of the term also equates to "harmful non-indigenous plants" of (Snyder & Kaufman, 2004):

> "Invasive species that are capable of invading natural plant communities where they displace indigenous species, contribute to species extinctions, alter the community structure, and may ultimately disrupt the function of ecosystem processes."

Invasives are in turn distinguished from "increasers," which are native species such as *Ericameria nauseosa* that respond favorably to increasing human stressors. Native increasers are treated under the "Native Species Composition" metric.

Apply To: All EIA modules and AA sizes.

Measurement Protocol: Table A-1 provides a draft list of commonly encountered invasive species for each Ecological System. Users may consider additional species as invasive for the purposes of this metric, so long as those species match the definitions given above and are recorded in the VEG2 comments section on the data sheet. Ideally, a comprehensive list of nonnative invasive species would be established for your program's area of interest in order to make the application of this metric as consistent as possible. Remember that not all nonnative plant species are invasive.

The protocol uses a visual estimation of absolute cover of invasive species, with each species summed to produce the total cover. The field survey method may be either (1) a Site Survey (semi-quantitative) method, in which the observers walk the entire occurrence (or assessment area within the occurrence) and take notes on native and total species cover, or (2) Quantitative Plot Data, where a fixed area is surveyed using either plots or transects. The plot or transect is typically a "rapid" plot, but a single intensive plot can also be taken. If plot data are used for this metric, it is important that the plot is representative of the larger system being assessed. In patchy ecosystems or large AAs, more than one plot may be desirable.

Table 24. Invasive Species Metric Rating.

Metric Rating	*Invasive Nonnative Plant Species Cover: ALL TYPES*
EXCELLENT (A)	Invasive nonnative plant species are absent from all strata or cover is very low (< 1% absolute cover).
GOOD (B)	Invasive nonnative plant species are present in at least one stratum, but sporadic (1-4 % cover).
FAIR (C)	Invasive nonnative plant species somewhat abundant in at least one stratum (4-10% cover).
FAIR/POOR (C-)	Invasive nonnative plant species are abundant in at least one stratum (10-30% cover).
POOR (D)	Invasive nonnative plant species are very abundant in at least one stratum (> 30% cover).

VEG3 Native Plant Species Composition

Definition: An assessment of overall species composition and diversity, including native diagnostic species, native decreasers, native increasers (e.g., "native invasives" of Richardson et al. (2000)), and evidence of species-specific diseases or mortality.

Background: This metric evaluates the degree of degradation to the native plant species, including decline in native species diversity and loss of key diagnostic species, as well as shifting dominance caused by positive response to stressors by native increasers (a.k.a., "native invasives", aggressive natives, successful competitors). Increaser species are native species whose dominance is indicative of degraded ecological conditions, such as heavy grazed or browsed occurrences (Daubenmire, 1968). Native increasers often have FQA coefficients of conservatism ≤ 3 (see Rocchio & Crawford, 2013 and http://www.dnr.wa.gov/NHP-FQA). Native decreasers are those species that decline rapidly due to stressors (i.e. species sensitive to human-induced disturbance or those species with FQA coefficients of conservatism ≥ 7). Diagnostic species, are native plant species whose relative constancy or abundance differentiates one vegetation type from another, including character species (strongly restricted to a type), differential species (higher constancy or abundance in a type as compared to others), constant species (typically found in a type, whether or not restricted), and dominant species (high abundance or cover) (FGDC 2008). Together these species also indicate certain ecological conditions, typically that of minimally disturbed sites. Degraded conditions caused by nonnative invasive species are covered in the "Invasive Plant Species Cover" metric.

Apply To: All EIA modules and AA sizes.

Measurement Protocol: The protocol requires a visual evaluation of variation in overall composition and requires the ability to recognize the major/dominant plant species of each layer or stratum. Lists of diagnostic species and common increasers and decreasers—for each Ecological

System—are available in Table A-1. The field survey method may be either (1) a Site Survey (semi-quantitative) method, in which the observers walk the entire occurrence (or assessment area within the occurrence) and take notes on native and total species cover, or (2) Quantitative Plot Data, where a fixed area is surveyed using either plots or transects. The plot or transect is typically a "rapid" plot, but a single intensive plot can also be taken. Using criteria in Table 25, assign ratings to submetrics on the field form.

Note: Native increasers can be difficult for many users to assess, as presence alone is not sufficient to indicate that these species are acting as increasers. Instead, it is their proportion relative to what is expected that triggers such a designation. This concept tends to work well in occurrences exposed to conspicuous stressors such as livestock grazing, where these species tend to dominate or become monocultures. **If you find this submetric difficult to evaluate, make a note in the comment section and skip it.**

Table 25. Native Plant Species Composition Rating Criteria.

Metric Rating	*Vegetation Composition: ALL TYPES*
EXCELLENT (A)	**Native plant species composition (species abundance and diversity) minimally to not disturbed:** Submetrics: i) DIAGNOSTICS: Typical range and diversity of native diagnostic species present. ii) NATIVE DECREASERS: Native species sensitive to anthropogenic degradation (native decreasers) present. iii) NATIVE INCREASERS: Native species indicative of anthropogenic disturbance (weedy or ruderal species) absent or, if naturally common in this type, present in expected amounts and not associated with conspicuous stressors.
GOOD (B)	**Native plant species composition with minor disturbed conditions:** Submetrics: i) DIAGNOSTICS: Some native diagnostic species absent (reduced diversity) or substantially reduced in abundance. ii) NATIVE DECREASERS: At least some native species sensitive to anthropogenic degradation present. iii) NATIVE INCREASERS: Native species indicative of anthropogenic disturbance (i.e. weedy or ruderal species) are present with low cover or, if naturally common in this type, present in slightly greater than expected amounts and associated with conspicuous stressors.
FAIR (C)	**Native plant species composition with moderately disturbed conditions:** Submetrics: i) DIAGNOSTICS: Many native diagnostic species absent (reduced diversity) or substantially reduced in abundance. ii) NATIVE DECREASERS: No native species sensitive to anthropogenic degradation present. iii) NATIVE INCREASERS: Native species indicative of anthropogenic disturbance (i.e. weedy or ruderal species) are present with moderate cover and associated with conspicuous stressors.

Metric Rating	*Vegetation Composition: ALL TYPES*
POOR (D)	**Native plant species composition with severely disturbed conditions:** Submetrics: i) DIAGNOSTICS: Most or all native diagnostic species absent (reduced diversity), a few may remain in very low abundance. Diagnostic species may be so few as to make the type difficult to key. ii) NATIVE INCREASERS: Native species indicative of anthropogenic disturbance (i.e. weedy or ruderal species) are present in high cover and associated with conspicuous stressors.

VEG4 Vegetation Structure

Definition: An assessment of the overall structural complexity of vegetation layers and growth forms, including presence of multiple strata and the age and structural complexity of the canopy layer. Vegetation structure provides evidence of the integrity of natural disturbance regimes, such as fire, avalanche, windthrow, mass wasting, and disease.

Background: This metric was originally drafted by NatureServe's Ecological Integrity Assessment Working Group (Faber-Langendoen et al., 2008). Modification to this metric for use in forested ecosystems borrows heavily from the work of Franklin et al. (2002) and Robert Van Pelt (2007, 2008) in outlining the natural stand development stages of Washington forests.

Apply To: All EIA modules and AA sizes (variant dependent on EIA module).

Measurement Protocol: This metric evaluates the horizontal and vertical structure of the vegetation relative to the reference condition of the dominant growth form's structural heterogeneity. Field survey data used to evaluate structure may consist of either 1) qualitative data where the observers walk the entire AA and make notes on vegetation structure, or 2) quantitative data, where a fixed area is surveyed, using either plots or transects. Assign metric/submetric rating based on appropriate variant rating criteria in Table 27. Due to the number of variables considered, a series of submetrics may be used to rate the metric.

<u>Forest Submetrics</u>: For forests, the protocol uses a visual evaluation of variation in overall structure of the tree stratum, with submetrics Canopy Structure and Large Live Trees.

CANOPY STRUCTURE: Assesses tree spacing, canopy layering, and overall structural heterogeneity. Note that snags are assessed within VEG6 Coarse Woody Debris, Snags, and Litter.

LARGE LIVE TREES: Assesses the number of tall, large diameter trees in the occurrence, as well as the frequency of stumps.

<u>Non-Forested Submetrics</u>: In non-forested types, the integrity of dominant growth forms is evaluated (e.g. whether shrubs have been removed, killed, or increased, or herbaceous layer has

been reduced or homogenized by anthropogenic stressors). Submetrics vary by EIA module, but may include:

SHRUB COVER: Assesses the relative cover of shrubs in shrublands.

TREE ENCROACHMENT: Assesses the relative cover of trees in shrublands.

WOODY VEGETATION COVER: Assesses the absolute cover of shrubs and/or trees in shrub-steppe and grasslands/meadows. In shrub-steppe, it also evaluates the prominence of fire-sensitive shrubs specifically (see Table 26).

Table 26. Fire-sensitive Shrubs of Shrub-Steppe Ecosystems.

Sensitive to Fire	NOT Sensitive to Fire
Artemisia tridentata ssp. wyomingensis	*Artemisia tripartita*
Artemisia tridentata ssp. tridentata	*Ericameria/Chrysothamnus sp.*
Artemisia tridentata ssp. vaseyana	*Ribes sp.*
Artemisia arbuscula	*Amelanchier sp.*
Purshia tridentata	*Tetradymia canescens*

BUNCHGRASS COVER: Assesses the relative cover of bunchgrasses in shrub-steppe and grasslands/meadows.

BIOLOGICAL SOIL CRUST: Assesses the continuity, diversity, and structure heterogeneity of lichens and mosses on the soil surface of shrub-steppe and grasslands/meadows.

Table 27. Vegetation Structure Variant Rating Criteria. Variants are provided in six separate tables by EIA module (group of Ecological Systems).

Metric Rating	*v7 Vegetation Structure Variant: DRY FORESTS & WOODLANDS*
EXCELLENT (A)	*Submetrics:* i. CANOPY STRUCTURE: **Oak Woodlands:** Multiple age or size classes of oak may be present but no single class dominates; Canopy architecture represents an appropriate mix of large open-grown trees and younger tree recruitment that will replace older trees when they die. Shrub cover is within the natural range of variability. In the East Cascades, percent live canopy ranges from 25-50%, with > 50% relative cover of oaks. West of the Cascades, total tree cover is 10-60%, shrub cover is also usually 10-60%, and moss + lichen cover is <= 25%. **Other dry forests/woodlands**: Vegetation structure is at or near minimally disturbed natural conditions. No structural indicators of degradation evident. ii. LARGE LIVE TREES: Very few, if any, cut stumps present. **Oak Woodlands**: West of the Cascades, large, mature (> 150 yrs old or > 60 cm DBH), widely spaced oaks with single trunks and broad spreading crowns present in a savanna setting. In the East Cascades, a cohort of mature oaks is prominent but not necessarily dominant in the canopy (a woodland). **Other dry forests/woodlands**: Varies by natural stand

Metric Rating	*v7 Vegetation Structure Variant: DRY FORESTS & WOODLANDS*
	development stage (Van Pelt, 2007 p27, 2008 p41): In mid to late seral stands (maturation to old-growth stages), large trees (> 50 cm DBH, > 150-200 yrs old) are present. Numbers of large trees range from > 20-25/ha in dry/dry-mesic mixed-conifer types to > 25-75/ha in Ponderosa and Larch savannas. Large trees may be absent from early seral stands (Biomass accumulation/stem exclusion stage or earlier), but if so, large stumps are also few or absent and there is evidence of a natural disturbance event (e.g., large downed wood from wind storms, or fire scars). Note: Low productivity sites (wooded steppes, savannas) may have old trees < than these diameters; use crown form, bark texture, and color to determine # of old trees in these sites. See Van Pelt (2007, 2008) for old tree indicators.
GOOD (B)	*Submetrics:* i. CANOPY STRUCTURE: **Oak Woodlands:** Fire suppression is allowing dense, even-aged sprouting to occur in some areas or in clumps along with relict open-grown trees. In the <u>East Cascades</u>, percent live canopy ranges from 25-50%, with 40-50% relative cover of oaks. West of the Cascades, tree cover is increasing, but the total is still acceptable (10-60%) over most of the stand. Shrub cover is within the natural range of variability (west of the Cascades: < =60% in oak-shrubland associations or < =10% in oak-herbaceous associations). In westside savannas, moss and lichen cover may be 25-40%. **Other Dry Forests/Woodlands:** Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor. ii. LARGE LIVE TREES: Cut stumps may be present, but there are more large trees than large cut stumps. No more than 30% of large, old trees have been harvested. **Oak Woodlands:** Relict large, mature (> 150 yrs old or > 60 cm DBH), widely spaced oaks with single trunks still present, but surrounded by dense small trees in some areas. **Other Dry Forests/Woodlands:** Some old (> 150-200 years) characteristic conifers are present (~10-20 live trees/ha > 50 cm DBH).
FAIR (C)	*Submetrics:* i. CANOPY STRUCTURE: **Oak Woodlands**: Dense, even-aged young cohort present, along with relict open-grown trees, across much of site. In the East Cascades, percent live canopy ranges from 15-25 or 50-60%, with > 20-40% relative cover of oaks. West of the Cascades, tree cover is acceptable (10-60%) in less than half the stand. Shrub cover is moderately outside the natural range of variability (west of the Cascades: 60-75% in oak-shrubland associations or 10-25% in oak-herbaceous associations). In westside savannas, moss and lichen cover may be 25-40%. **Other Dry Forests/Woodlands:** Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate. ii. LARGE LIVE TREES: Cut stumps are present and large stumps may slightly outnumber large trees. 30-60% of large, old trees have been harvested. **Oak Woodlands:** Few large, open-grown oaks (> 150 yrs old or > 60 cm DBH) present and remaining examples are surrounded by dense small trees. Most oaks are < 100 yrs old. **Other Dry Forests/Woodlands:** Generally fewer than 10 live trees/ha > 50 cm DBH.

Metric Rating	*v7 Vegetation Structure Variant: DRY FORESTS & WOODLANDS*
POOR (D)	*Submetrics*: i. CANOPY STRUCTURE: **Oak Woodlands**: Single age class of oaks present. In the East Cascades, percent live canopy is typically < 15% or > 60%, with < 20% relative cover of oaks. West of the Cascades, tree cover is > 60% over most of the stand. Shrub cover is well outside the natural range of variability (west of the Cascades: > 75% in oak-shrubland associations or > 25% in oak-herbaceous associations). In westside savannas, moss and lichen cover may be > 40%. **Other Dry Forests/Woodlands:** Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong. ii. LARGE LIVE TREES: Cut stumps are present and large stumps greatly outnumber large trees. > 60% of large, old trees have been harvested. **Oak Woodlands**: All oak trees < 100 yrs. old with no large trees. **Other Dry Forests/Woodlands:** < 5 live trees/ha > 50 cm DBH.

Metric Rating	*v8 Vegetation Structure Variant: MESIC / HYPERMARITIME FORESTS*
EXCELLENT (A)	*Submetrics:* i. CANOPY STRUCTURE: Vegetation structure is at or near minimally disturbed natural conditions. No structural indicators of degradation evident. **Subalpine Parklands**: Canopy structure consists of clumps of trees (often dense and up to 0.1 ha in area, or more) interspersed with low shrublands and meadows. **Aspen Forests and Woodlands**: Conifers are limited to understory or < 10% of canopy (note: aspen stems may be small if resprouting from recent fire). **Other Mesic / Hypermaritime Forests:** A deep, multilayered canopy is present with a full range of canopy strata, tree heights, and tree diameters (small = 5-24 cm, moderate = 25-49 cm, large = 50-99 cm, and > 100 cm). ii. LARGE LIVE TREES: Few, if any, cut stumps present. **Non-Aspen Forests and Woodlands**: Clusters of old (> 150 years) characteristic conifers prominent (> 20 live trees/ha > 50 cm DBH). Trees > 100 cm present. See Van Pelt (2007) for old tree indicators.
GOOD (B)	*Submetrics:* i. CANOPY STRUCTURE: Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor. **Aspen Forests and Woodlands**: Conifers make up 10-25% of canopy and some evidence of fire exclusion and/or excessive herbivory. **Other Mesic / Hypermaritime Forests:** Moderate range of canopy strata, tree heights and tree diameters. ii. LARGE LIVE TREES: Cut stumps may be present, but there are more large trees than large cut stumps. No more than 30% of large, old trees have been harvested. **Non-Aspen Forests and Woodlands**: Some old (> 150 years) characteristic conifers are present (~10-20 live trees/ha > 50 cm DBH). Some trees > 100 cm may be present.

Metric Rating	*v8 Vegetation Structure Variant: MESIC / HYPERMARITIME FORESTS*
FAIR (C)	*Submetrics:* i. CANOPY STRUCTURE: Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate. **Aspen Forests and Woodlands**: Conifers make up 25-50% of canopy and evidence of fire exclusion and/or excessive herbivory. **Other Types**: Small range of canopy strata, tree heights and tree diameters. ii. LARGE LIVE TREES: Cut stumps are present and large stumps may slightly outnumber large trees. 30-60% of large, old trees have been harvested. **Non-Aspen Forests and Woodlands:** Generally fewer than 10 live trees/ha > 50 cm DBH. Trees > 100 cm present absent.
POOR (D)	*Submetrics:* i. CANOPY STRUCTURE: Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong. **Aspen Forests and Woodlands**: Conifers make up > 50% of canopy and evidence of fire exclusion and/or excessive herbivory. **Other Types**: Single cohort present. Homogeneous canopy with narrow range of canopy strata, tree heights and tree diameters. ii. LARGE LIVE TREES: Cut stumps are present and large stumps greatly outnumber large trees. > 60% of large, old trees have been harvested. **Non-Aspen Forests and Woodlands:** < 5 live trees/ha > 50 cm DBH. Trees > 100 cm present absent.

Metric Rating	*v9 Vegetation Structure Variant: SHRUBLANDS*
EXCELLENT (A)	Vegetation structure is at or near minimally disturbed natural conditions. No structural indicators of degradation evident. *Submetrics:* i. SHRUB COVER: Relative cover of shrubs is 50-100% with no signs of reduction from anthropogenic stressors. ii. TREE ENCROACHMENT: Trees are absent or minimal.
GOOD (B)	Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor. *Submetrics:* i. SHRUB COVER: Due to anthropogenic stressors, relative shrub cover slightly decreased from NRV. ii. TREE ENCROACHMENT: When present, trees are generally shorter than shrubs and 1-10% cover.
FAIR (C)	Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate. *Submetrics:* i. SHRUB COVER: Due to anthropogenic stressors, relative shrub cover moderately decreased from NRV. ii. TREE ENCROACHMENT: Trees are generally pole-sized or smaller (susceptible to fire mortality) and have 1-10% cover.

Metric Rating	*v9 Vegetation Structure Variant: SHRUBLANDS*
POOR (D)	Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong. *Submetrics:* i. SHRUB COVER: Relative shrub cover greatly reduced by anthropogenic stressors (relative cover may be < 50%) ii. TREE ENCROACHMENT: Trees are generally larger than pole-sized (not susceptible to fire mortality) and have > 10% cover.

Metric Rating	*v10 Vegetation Structure Variant: SHRUB-STEPPE*
EXCELLENT (A)	Vegetation structure is at or near minimally disturbed natural conditions. No structural indicators of degradation evident. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees have minimal cover (< 5%) and are well-spaced when present. Fire-sensitive shrubs (see Table 26) mature and recovered from past fires. ii. BUNCHGRASS COVER: Perennial bunchgrass relative cover > 80% OR cover near site potential. iii. BIOLOGICAL SOIL CRUST: Biological soil crust is largely intact, with a rough surface texture and high diversity of lichens and/or mosses (often 7+)--nearly matching the site capability where natural site characteristics are not limiting (e.g. steep, unstable terrain; draws with significant water runoff; south-facing aspects; areas with dense native grass).
GOOD (B)	Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees are present with moderate cover (5-10%). Fire-sensitive shrubs (see Table 26) common, but not fully recovered from past fires. ii. BUNCHGRASS COVER: Perennial bunchgrasses 50-80% relative cover OR reduced from site potential. iii. BIOLOGICAL SOIL CRUST: Biological soil crust is evident throughout the site and diverse (> 3 species prominent), but its continuity is broken and structure may be simplified (decreased roughness of surface texture).
FAIR (C)	Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees are present with moderate cover (10-25%). Fire-sensitive shrubs (see Table 26) present and recovering from past fires. ii. BUNCHGRASS COVER: Perennial bunchgrasses 30-50% relative cover OR reduced from site potential.

Metric Rating	*v10 Vegetation Structure Variant: SHRUB-STEPPE*
	iii. BIOLOGICAL SOIL CRUST: Biological soil crust is present, but only in protected areas and with a minor component elsewhere. Species diversity is low (< 3 species) and structure is simplified (not rough).
POOR (D)	Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong. *Submetrics:* i. WOODY VEGETATION COVER: Fire-sensitive shrubs (see Table 26) rare due to past fires. Shrubs (taller than grass layer) and trees are present with high cover (> 25%). ii. BUNCHGRASS COVER: Perennial bunchgrass < 30% relative cover AND much reduced from site potential. iii. BIOLOGICAL SOIL CRUST: Biological soil crust, if present, is found only in protected areas and with little diversity and/or simplified structure (not rough).

Metric Rating	*v11 Vegetation Structure Variant: GRASSLANDS / MEADOWS*
EXCELLENT (A)	Vegetation structure is at or near minimally disturbed natural conditions. No structural indicators of degradation evident. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees have minimal cover (< 5%) and are well-spaced when present. ii. BUNCHGRASS COVER: Perennial bunchgrass relative cover > 80% OR cover near site potential. iii. BIOLOGICAL SOIL CRUST: **Willamette Valley Upland Prairie and Savanna**: Bryophyte and lichen cover is < 25%, consisting of short, dense turf mosses, short-lived and ephemeral mosses, and leafy liverworts AND with little to no cover of lichens, perennial feather mosses, and tall turf mosses outside of scattered refugia. **All Other Grasslands**: If expected, biological soil crust is largely intact, with a rough surface texture and high diversity of lichens and/or mosses (often 7+)--nearly matching the site capability where natural site characteristics are not limiting (e.g. steep, unstable terrain; draws with significant water runoff; south-facing aspects; areas with dense native grass).
GOOD (B)	Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees are present with moderate cover (5-10%). ii. BUNCHGRASS COVER: Perennial bunchgrasses 50-80% relative cover OR reduced from site potential. iii. BIOLOGICAL SOIL CRUST: **Willamette Valley Upland Prairie and Savanna**: Bryophyte and lichen cover is 25-40%, primarily consisting of short, dense turf mosses, short-

Metric Rating	*v11 Vegetation Structure Variant: GRASSLANDS / MEADOWS*
	lived and ephemeral mosses, and leafy liverworts, but also with perennial feather mosses, tall turf mosses, and some lichens present throughout the stand. **All Other Grasslands**: If expected, biological soil crust is evident throughout the site and diverse (> 3 species prominent), but its continuity is broken and structure may be simplified (decreased roughness of surface texture).
FAIR (C)	Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees are present with moderate cover (10-25%). ii. BUNCHGRASS COVER: Perennial bunchgrasses 30-50% relative cover OR reduced from site potential. iii. BIOLOGICAL SOIL CRUST: **Willamette Valley Upland Prairie and Savanna**: Bryophyte and lichen cover is 25-40%, primarily consisting of perennial feather mosses, tall turf mosses, and lichens, but also with short, dense turf mosses, short-lived and ephemeral mosses, and leafy liverworts present throughout the stand. **All Other Grasslands**: If expected, biological soil crust is present, but only in protected areas and with a minor component elsewhere. Species diversity is low (< 3 species) and structure is simplified (not rough).
POOR (D)	Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong. *Submetrics:* i. WOODY VEGETATION COVER: Shrubs (taller than grass layer) and trees are present with high cover (> 25%). ii. BUNCHGRASS COVER: Perennial bunchgrass < 30% relative cover AND much reduced from site potential. iii. BIOLOGICAL SOIL CRUST: **Willamette Valley Upland Prairie and Savanna**: Bryophytes and lichens are abundant, with cover > 40%, primarily consisting of perennial feather mosses, tall turf mosses, and lichens. **All Other Grasslands**: If expected, biological soil crust is absent or found only in protected areas and with little diversity and/or simplified structure (not rough).

Metric Rating	*v12 Vegetation Structure Variant: BEDROCK / CLIFFS*
EXCELLENT (A)	Vegetation structure is at or near minimally disturbed natural conditions. Shrub and herb strata at expected levels of abundance and diversity and/or low cover of shrubs or trees, where appropriate. Overall, no evidence of human-related degradation.
GOOD (B)	Vegetation structure shows minor alterations from minimally disturbed natural conditions. Structural indicators of degradation are minor.
FAIR (C)	Vegetation structure is moderately altered from minimally disturbed natural conditions. Structural indicators of degradation are moderate.

Metric Rating	*v12 Vegetation Structure Variant: BEDROCK / CLIFFS*
POOR (D)	Vegetation structure is greatly altered from minimally disturbed natural conditions. Structural indicators of degradation are strong.

VEG5 Woody Regeneration

Definition An assessment of tree or tall shrub regeneration.

Background: This metric was developed by NatureServe and WNHP. It combines both structural and compositional information, in that regeneration abundance is assessed with respect to native woody species. Woody Regeneration serves as one of the proxy measures for natural disturbance, particularly fire regime.

Apply To: Dry Forests & Woodlands (v2) and Mesic / Hypermaritime Forests (v3) of all AA sizes.

Measurement Protocol: This metric evaluates the tree and shrub regeneration layer (tree seedlings and shrubs < 1.3 m tall and saplings > 1.3 m tall AND ≤ 10 cm DBH). It requires a visual estimation of tree seedling and sapling abundance and/or young shrub growth. The field survey method for estimating woody regeneration may either be (1) a Site Survey (semi-quantitative) method where the observers walk the entire AA and take notes on regeneration of woody species, or (2) Quantitative Plot Data, where a fixed area is surveyed, using either plots or transects. Consult Van Pelt (2007, 2008) for a general idea of the amount of woody regeneration to be expected for a particular stand development stage. Assign metric rating based on appropriate variant rating criteria in Table 28.

Table 28. Woody Regeneration Ratings.

Metric Rating	*v2 Woody Regeneration: DRY FORESTS & WOODLANDS*
EXCELLENT (A)	Native, fire-tolerant tree saplings and/or seedlings or fire-tolerant shrubs common to the type present in expected amounts and diversity for the stand development stage. All trees originated from natural regeneration. Regeneration is limited and occurs in natural gaps or in small clusters within an older stand. Fire-sensitive species, if present, are regenerating only in small refugia.
GOOD (B)	Native, fire-tolerant tree saplings and/or seedlings or fire-tolerant shrubs common to the type present, but in greater than expected density due to anthropogenic stressors (e.g., grazing opening germination opportunities, decreasing competition from herbaceous species, and/or removing fine fuels, etc.). Some of the trees may have been planted but most originate from natural regeneration. Regeneration is occurring outside of natural gaps, moist sites, or protected sites (10-25% of site). Fire-sensitive species (not indicative of the type) may be present and associated with few signs of recent fire (e.g., no charred trees, significant fine litter accumulation, etc.).

Metric Rating	*v2 Woody Regeneration: DRY FORESTS & WOODLANDS*
FAIR (C)	Native fire-tolerant tree saplings and/or seedlings or fire-tolerant shrubs common to the type present but in much greater than expected density due to anthropogenic stressors (e.g., grazing opening germination opportunities, decreasing competition from herbaceous species, and/or removing fine fuels, etc.) OR fire-sensitive species (not indicative of the type) present and becoming abundant and associated with few signs of recent fire (e.g., no charred trees, significant fine litter accumulation, etc.). There may be evidence that many trees were planted, though most originate from natural regeneration. Regeneration occurring outside of natural gaps, moist sites, or protected sites (25-50% of site).
POOR (D)	Dense regeneration dominated by fire-sensitive species not indicative of the type and associated with lack of recent fire (e.g., no charred trees, significant fine litter accumulation, etc.) OR diagnostic species not regenerating OR evidence that over half the trees were planted.

Metric Rating	*V3 Woody Regeneration: MESIC / HYPERMARITIME FORESTS*
EXCELLENT (A)	Native tree saplings and/or seedlings or shrubs common to the type present in expected amounts and diversity for the stand development stage; obvious regeneration where expected for the species (e.g. in gaps caused by windthrow or other natural disturbances, *Tsuga heterophylla* on nurse logs, *Pseudotsuga menziesii* on bare/burned mineral soil). All trees originated from natural regeneration. **Hypermaritime Forests**: Elk browsing is neither excluded nor concentrated (browsing has created a relatively open understory). **Aspen Forests and Woodlands**: Abundant regeneration with little sign of browsing of smaller sprouts and seedlings (> 1.5 m tall, < 3 cm DBH).
GOOD (B)	Native tree saplings and/or seedlings or shrubs common to the type present, but in lower amounts and diversity than expected for the stand development stage. Some of the trees may have been planted but most originate from natural regeneration. **Hypermaritime Forests**: Elk browsing is either excluded or unnaturally concentrated and effect on regeneration has a slight negative impact. **Aspen Forests and Woodlands**: Regeneration is prominent, but with some noticeable damage to sprouts and seedlings (> 1.5 m tall, < 3 cm DBH) from browsing.
FAIR (C)	Native tree saplings and/or seedling or shrubs common to the type present, but in low amounts and diversity OR evidence that many trees were planted, though most originate from natural regeneration. **Hypermaritime Forests**: Elk browsing is either excluded or unnaturally concentrated and effect on regeneration has a moderate negative impact. **Aspen Forests and Woodlands**: Regeneration is merely present OR most sprouts have been damaged by browsing and there is a noticeable lack of seedlings (> 1.5 m tall, < 3 cm DBH).
POOR (D)	Essentially no regeneration of native woody species common to the type OR evidence that over half the trees were planted. **Hypermaritime Forests**: Elk browsing is either excluded or unnaturally concentrated and effect on regeneration has a severe negative impact. **Aspen Forests and Woodlands**: Regeneration is absent or nearly so. Any remaining sprouts have been damaged by browsing.

VEG6 Coarse Woody Debris, Snags, and Litter

Definition An assessment of coarse woody debris (CWD, i.e. logs and branches), as well as standing dead snags and litter.

Background: Particularly in forested systems, woody debris (including snags) plays a critical role in a variety of ecosystem processes. It is a primary driver of carbon and other nutrient cycles (Harmon & Hua, 1991; North et al., 1997; Luyssaert et al., 2008), influences soil moisture (Marra & Edmonds, 1996) and seedling establishment success (Christy & Mack, 1984), and provides microhabitat for invertebrates, fungi, and bryophytes (Marra & Edmonds, 1998), in addition to habitat for birds and small mammals (Bull, 2002). CWD also varies based on the stand development stage and natural disturbance history (Franklin et al., 2002). In general, altered levels of coarse woody debris may indicate a history of logging or other woody vegetation removal, overgrazing, invasive plant colonization, and altered fire regimes.

While creating the metric variant for Dry Forests & Woodlands (v3), the following stressor/condition relationships were considered:

- Fire suppression results in more infrequent, higher intensity fires in these types, leading to greater accumulation of fuels, including snags. Accumulation can be a direct result of reduced consumption by fire, or increased CWD production and tree mortality related to tree density.
- Pathogen outbreaks increase CWD and snags through increased mortality.
- Overgrazing results in reduction of fine fuels.
- Invasive plants—primarily exotic grasses—increase fine fuel loads
- Logging results in reduction of large fuels and snags, but small fuel loads are dependent on the harvesting method, slash burning, etc. Early seral forests with few snags might indicate a history of logging, instead of fire.

Mesic / Hypermaritime Forests (v4) experience fewer CWD stressors, as fire, grazing, and invasive plants are minor components of these systems. The primary stressors considered during development of this variant were logging history and (to a lesser extent) landscape fragmentation.

- As in Dry Forests & Woodlands, logging reduces large CWD and snags, with small fuel impacts dependent on harvesting practices.
- Pathogen outbreaks also increase CWD and snags through increased mortality.
- Landscape fragmentation can cause increased windthrow due to edge effects.

This metric also addresses litter in grassland systems. In grasslands, excess litter can affect germination (Rotundo & Aguiar, 2005), potentially alter biological soil crusts (Belnap et al., 2001), and lead to more intense fires and corresponding exotic plant invasions (D'Antonio & Vitousek, 1992).

Apply To: *Required* for Dry Forests & Woodlands (v3) and Mesic / Hypermaritime Forests (v4). *Optional* for Grasslands / Meadows (v5).

Measurement Protocol: Estimation of coarse woody debris may be based on either 1) qualitative data, where the observers walk the entire AA and make notes on debris size, quantity, and degree of decomposition, or 2) quantitative data, where a fixed area is surveyed, using either plots or transects. Assign metric rating based on appropriate variant rating criteria in Table 29.

<u>v3 Dry Forests & Woodlands and v4 Mesic / Hypermaritime Forests</u>: Pay special attention to the amount of coarse woody debris (including snags) when surveying the AA and remember that levels of debris will vary naturally with stand development stage. Note signs of pathogen outbreaks (bore holes, blisters, conks, etc.), grazing (tracks, scat, vegetation denuded below a certain height), and indications that fine fuels are from nonnative plants (using structural clues like diameter, old inflorescences, accumulation at base of live nonnatives, etc.). These two variants are divided into separate submetrics for CWD and snags.

<u>v5 Grasslands / Meadows</u>: Note the quantity and distribution of litter compared with the baseline expected in the landscape. Litter is often detached from the live plant, but dead plant material at the base of plants (growth from the prior year or before) is also considered litter. Be sure the assessment of litter is not based on seasonality (i.e., when a grassland is surveyed early in the year, the prior years' desiccated vegetation can appear more dense than later in the season because most new growth has yet to occur). This variant is difficult to measure unless the user has considerable field experience with the type in question. As such, it is considered an optional metric.

Table 29. Coarse Woody Debris Ratings. Seral class follows Van Pelt (2007, 2008). Early Seral = cohort establishment to biomass accumulation/stem exclusion phases; Mature = maturation phase; Old-Growth = vertical diversification, horizontal diversification, and pioneer cohort loss phases.

Metric Rating	*Sub metric*	*v3 Coarse Woody Debris, Snags, & Litter: DRY FORESTS & WOODLANDS*		
		Early Seral	Mature	Old-Growth
EXCELLENT (A)	CWD	Accumulation of fine fuels (such as grass litter) appears to have been limited by ground fires and not by overgrazing. No evidence that CWD has been reduced by logging activities; no logging slash and no burned slash piles. Forests in the Columbia River Gorge often have large amounts of CWD due to wind/ice storms, but there is no evidence of increased windthrow attributable to fragmentation of the surrounding landscape.	May be limited to charred stumps in mature stands (indicating periodic, low-intensity fires). Accumulation of fine fuels (such as grass litter) appears to have been limited by ground fires and not by overgrazing. No evidence that CWD has been reduced by logging activities; no logging slash and no burned slash piles.	May be limited to large logs that are not consumable in a single fire (indicating periodic, low-intensity fires). Accumulation of fine fuels (such as grass litter) appears to have been limited by ground fires and not by overgrazing. No evidence that CWD has been reduced by logging activities; no logging slash and no burned slash piles.
	SNAGS	Stands regenerating after natural disturbance may have numerous snags (legacies of the previous stand) in early stages of decay.	May have few snags, as most legacies of the previous stand have decayed.	Characteristically have large snags of wide decay-class diversity present throughout.
GOOD (B)	CWD	Considering the natural stand development stage (Van Pelt, 2007 p27, 2008 p41), these forests have moderately altered CWD proportions due to fire suppression, overgrazing, invasive plants, exotic pathogens, and/or past logging. Large CWD has been moderately reduced and may be sporadic due to logging OR landscape fragmentation (windthrow) or decreased fire frequency has resulted in moderately increased amounts of CWD, either through reduced consumption by fire or increased CWD production related to tree density. This includes fallen mortality from pine beetles (*Dendroctonus* sp., etc.) and other forest outbreaks related to density. Fine fuels (such as grass litter) are beginning to accumulate OR appear to have been reduced by grazing. Evidence of minor logging slash OR isolated slash pile burn sites may be present.		

Metric Rating	*Sub metric*	*v3 Coarse Woody Debris, Snags, & Litter: DRY FORESTS & WOODLANDS*		
		Early Seral	Mature	Old-Growth
	SNAGS	Considering the natural stand development stage (Van Pelt, 2007 p27, 2008 p41), these forests have moderately altered snag proportions. May have fewer legacy snags than expected, indicating establishment after logging, rather than fire.	Considering the natural stand development stage, these forests have moderately altered snag proportions. Snags in early stages of decay are moderately more common than expected due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks.	
FAIR (C)	CWD	Considering the natural stand development stage, these forests have significantly altered CWD proportions due to fire suppression, overgrazing, invasive plants, exotic pathogens, and/or past logging. Large CWD has been significantly reduced and may be nearly absent due to logging OR landscape fragmentation (windthrow) or decreased fire frequency has resulted in significantly increased amounts of CWD, either through reduced consumption by fire or increased CWD production related to tree density. This includes fallen mortality from pine beetles (*Dendroctonus* sp., etc.) and other forest outbreaks related to density. Fine fuels (such as grass litter) have significant accumulation OR appear to have been significantly reduced by overgrazing. Evidence of significant logging slash OR slash pile burn sites are common.		
	SNAGS	Considering the natural stand development stage, these forests have significantly altered snag proportions. May have very few legacy snags, indicating establishment after logging, rather than fire.	Considering the natural stand development stage, these forests have significantly altered snag proportions. Snags in early stages of decay are significantly more common than expected due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks.	
POOR (D)	CWD	Considering the natural stand development stage, these forests have extremely altered CWD proportions due to pervasive fire suppression, overgrazing, invasive plants, exotic pathogens, or past logging. Large CWD is essentially absent due to logging OR landscape fragmentation (windthrow) or fire suppression has resulted in jackpots of CWD, either through elimination of consumption by fire or increased CWD production related to tree density. This includes fallen mortality from pine beetles (*Dendroctonus* sp., etc.) and other forest outbreaks related to density. Fine fuels (such as grass litter) have accumulated to great depth OR appear to have been nearly eliminated by overgrazing. Pervasive logging slash OR slash pile burn sites are abundant.		

Metric Rating	*Sub metric*	*v3 Coarse Woody Debris, Snags, & Litter: DRY FORESTS & WOODLANDS*		
		Early Seral	Mature	Old-Growth
	SNAGS	Considering the natural stand development stage, these forests have extremely altered snag proportions. Snags in early stages of decay are pervasive throughout due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. Early seral forests (cohort establishment to biomass accumulation/stem exclusion stages) have no legacy snags, indicating establishment after logging, rather than fire.	Considering the natural stand development stage, these forests have extremely altered snag proportions. Snags in early stages of decay are pervasive throughout due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks.	

Metric Rating	*Sub metric*	*v4 Coarse Woody Debris, Snags, & Litter: MESIC / HYPERMARITIME FORESTS*		
		Early Seral	Mature	Old-Growth
EXCELLENT (A)	CWD	Stands that regenerate after natural disturbance may have abundant CWD of wide size-class diversity, but limited decay-class. Stands in the biomass accumulation/competitive exclusion stage often have abundant small-diameter, highly decayed CWD. No evidence that CWD has been reduced by logging activities; no logging slash and no burned slash piles. Coastal, hypermaritime forests often have large amounts of CWD, but there is no evidence of increased windthrow attributable to fragmentation of the surrounding landscape.	Moderate to high numbers of logs of diverse decay classes. No evidence that CWD has been reduced by logging activities; no logging slash and no burned slash piles. Coastal, hypermaritime forests often have large amounts of CWD, but there is no evidence of increased windthrow attributable to fragmentation of the surrounding landscape.	

Metric Rating	*Sub metric*	*v4 Coarse Woody Debris, Snags, & Litter: MESIC / HYPERMARITIME FORESTS* Early Seral	Mature	Old-Growth
	SNAGS	Stands regenerating after natural disturbance may have numerous snags (legacies of the previous stand) of wide size-class diversity, but limited decay-class diversity. Note that coastal, hypermaritime forests subject to severe wind storms may have significantly fewer snags.	May have few snags, as most legacies of the previous stand have decayed.	Characteristically have large snags of wide decay-class diversity present throughout. Note that coastal, hypermaritime forests subject to severe wind storms may have significantly fewer snags.
GOOD (B)	CWD	Considering the natural stand development stage (Van Pelt, 2007 p27, 2008 p41), these forests have moderately reduced CWD proportions and decay-class diversity due to past logging OR moderately *increased* CWD due to mortality from pine beetles (Dendroctonus sp., etc.) or other density-related forest outbreaks. CWD remains within NRV, but large CWD has been moderately reduced and may be sporadic. Evidence of minor logging slash OR isolated slash pile burn sites is present. Coastal, hypermaritime forests have some evidence of moderately increased windthrow due to fragmentation of the surrounding landscape.		
GOOD (B)	SNAGS	Considering the natural stand development stage, these forests have moderately reduced snag numbers due to past logging OR snags in early stages of decay are moderately more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. May have fewer legacy snags than expected, indicating establishment after logging, rather than fire. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	Considering the natural stand development stage, these forests have moderately reduced snag numbers due to past logging OR snags in early stages of decay are moderately more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	

Metric Rating	*Sub metric*	*v4 Coarse Woody Debris, Snags, & Litter: MESIC / HYPERMARITIME FORESTS*		
		Early Seral	Mature	Old-Growth
FAIR (C)	CWD	Considering the natural stand development stage, these forests have significantly reduced CWD proportions and decay-class diversity due to past logging OR significantly *increased* CWD due to mortality from pine beetles (Dendroctonus sp., etc.) or other density-related forest outbreaks. CWD is outside NRV, large CWD has been significantly reduced and may be hard to find. Evidence of significant logging slash OR slash pile burn sites are common. Coastal, hypermaritime forests have some evidence of significantly increased windthrow due to increased fragmentation of the surrounding landscape.		
	SNAGS	Considering the natural stand development stage, these forests have significantly reduced snag numbers due to past logging OR snags in early stages of decay are significantly more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. These stands may have very few legacy snags, indicating establishment after logging, rather than fire. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	Considering the natural stand development stage, these forests have significantly reduced snag numbers due to past logging OR snags in early stages of decay are significantly more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	
POOR (D)	CWD	Considering the natural stand development stage, these forests have extremely reduced CWD proportions and decay-class diversity due to pervasive past logging OR extremely *increased* CWD due to mortality from pine beetles (Dendroctonus sp., etc.) or other density-related forest outbreaks. CWD is well outside NRV, large CWD has been eliminated. Pervasive logging slash OR slash pile burn sites are abundant. Coastal, hypermaritime forests are clearly experiencing significantly increased windthrow due to major fragmentation of the surrounding landscape.		

Metric Rating	*Sub metric*	*v4 Coarse Woody Debris, Snags, & Litter: MESIC / HYPERMARITIME FORESTS*		
		Early Seral	Mature	Old-Growth
	SNAGS	Considering the natural stand development stage, these forests have extremely reduced snag numbers due to past logging OR snags in early stages of decay are significantly more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. These stands may have no legacy snags, indicating establishment after logging, rather than fire. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	Considering the natural stand development stage, these forests have extremely reduced snag numbers due to past logging OR snags in early stages of decay are significantly more common than expected in mature and old-growth stands due to pine beetles (*Dendroctonus* sp., etc.) or other forest outbreaks. Note that coastal, hypermaritime forests may naturally have few or no legacy snags due to major windthrow events.	

Metric Rating	*v5 Coarse Woody Debris, Snags, & Litter: GRASSLANDS / MEADOWS*
EXCELLENT (A)	Considering climate and weather, litter is present but with minimal accumulation (accumulation is greater in cold and moist grasslands than hot and dry grasslands). Site productivity or regular burning limits it to a thin layer of recently deposited material (generally < 20 % cover, < 0.5 cm deep other than beneath mature shrubs). Accumulation does not appear to reduce seedling germination or species diversity. Nutrient and water availability, disease, and herbivory incidence appear to be within NRV.
GOOD (B)	Considering climate and weather, litter accumulation is beginning to exceed expected amounts (roughly 20-30% cover, 0.5-2 cm deep outside shrub canopies). Localized impacts on seedling germination or survival may be occurring due to patchy accumulation of litter beyond the NRV. Nutrient and water availability, disease, and herbivory incidence may be slightly outside NRV.
FAIR (C)	Considering climate and weather, there is significant accumulation of litter (roughly 30-50% cover, 2-5 cm deep outside shrub canopies). Seedling germination and diversity is reduced and may be limited to favorable microsites. Nutrient and water availability, disease, and herbivory incidence are outside NRV.
POOR (D)	Fire exclusion or shifts in species composition have allowed widespread, very deep accumulation of litter (roughly > 50% cover, > 5 cm deep outside shrub canopies). Litter has nearly eliminated establishment of seedlings. Nutrient and water availability, disease, and herbivory incidence are significantly outside NRV.

3. 9 SOIL / SUBSTRATE

Conducting rapid assessments of soil condition is challenging, and here we limit the assessment to visible evidence of soil surface or soil profile alterations that degrade the soil structure, as well as obvious signs of soil moisture degradation due to anthropogenic stressors.

SOI1 Soil Condition

Definition: An indirect measure of soil condition based on stressors that increase the potential for erosion or sedimentation. Soil condition is evaluated based on intensity of human impacts to soils on the site. Anthropogenic alterations to soil moisture are also considered here.

Background: This metric is partly based on one developed by Mack (2001) and the NatureServe Ecological Integrity Working Group (Faber-Langendoen et al., 2008). This metric has also been called "Substrate / Soil Disturbance."

Apply To: All EIA modules and AA sizes.

Measurement Protocol: Prior to fieldwork, aerial photography of the site can be reviewed to determine if any soil alterations have occurred, but the primary assessment is based on field observations of the AA. Assign metric rating based on appropriate variant rating criteria in Table 30.

Table 30. Soil Condition Rating Criteria.

Metric Rating	*Soil Surface Condition: ALL TYPES*
EXCELLENT (A)	Undisturbed, with little bare soil OR bare soil is limited to naturally caused disturbances such as frost heaving, blowouts, burrowing, or game trails OR substrate is naturally bare (balds, sand dunes, etc.). On naturally unstable substrates, slope movements have not been altered directly by human activities. Natural water erosion may occur on slopes. No disturbances are evident from human- or livestock-induced trampling, erosion, soil compaction, ruts, or sedimentation. Soil layers are intact and there are no management-created platy soils. No changes in soil moisture availability due to anthropogenic impacts (e.g. raised water table due to tree removal in mesic/subhydric sites, lowered water table due to downcutting of streams by grazing animals, decreased soil moisture due to overgrazing, excess water from irrigation seepage, logging roads diverting water, soil compaction reducing infiltration).
GOOD (B)	Small amounts of bare or disturbed soil from anthropogenic activities are present, with minimal extent and impact. Examples include disturbance from cattle (trampling or heavy grazing that leads to erosion), compaction by machinery or particularly heavy foot traffic, or ruts or other disturbances from ATV or other vehicular activity. The depth of disturbance is limited to only a few inches (several centimeters) and does not show evidence of active displaced litter, pedestals, and/or terracettes. Soil layers are generally intact, though soil structure may be discontinuously changed to platy (soil pedestals wider than tall) or massive (essentially structureless) in places. On naturally unstable substrates, slope movements have been minimally altered by human activities (< 10% of area). Nearly natural pattern of water movement and infiltration, minor erosion on slopes. Minor impacts to evaporative processes and/or water table levels have occurred due to anthropogenic causes.
FAIR (C)	Moderate amounts of bare or disturbed soil from anthropogenic activities are present and the extent and impact is moderate. Examples include disturbance from cattle (trampling or heavy grazing that leads to erosion), compaction by machinery or particularly heavy foot traffic, or ruts or other disturbances from ATV or other vehicular activity. The depth of disturbance may extend 5-10 cm (2-4 in), with localized deeper ruts. Moderate evidence of exposed roots, displaced litter, pedestals and/or terracettes. On naturally unstable substrates, slope movements have been moderately altered directly by human activities (10-25% of area). Apparent changes in natural pattern of water movement and infiltration, with occasional erosion on slopes. Forest-floor duff and litter layers are partially missing. Surface soil is partially intact and maybe mixed with subsoil; structure may be changed from undisturbed conditions and may be platy or massive. Moderate impacts to evaporative processes and/or water table levels have occurred due to anthropogenic causes.
POOR (D)	Substantial amounts of bare or disturbed soil from anthropogenic activities are present, with extensive and long lasting impacts to natural processes. Examples include disturbance from cattle (trampling or heavy grazing that leads to erosion), compaction or trampling by machinery, or deep ruts or other disturbances from ATV or other vehicular activity. The depth of disturbance or compaction is persistent and extends > 10 cm (4 in). Common evidence of exposed roots, displaced litter, pedestals and/or terracettes. On naturally unstable substrates, slope movements have been severely altered by human activities (> 25% of area). Obvious changes in natural pattern of water movement and infiltration, active erosion on slopes, water is

Metric Rating	*Soil Surface Condition: ALL TYPES*
	channeled or ponded. Forest-floor duff and litter layers are missing. Surface soil is removed through gouging or piling by machinery and overall structure may be platy or massive throughout. Significant impacts to evaporative processes and/or water table levels have occurred due to anthropogenic causes have pushed soil moisture well outside of NRV. Altered soil moisture is resulting in mortality of numerous species and plant community composition change.

3.10 SIZE

The role of size in EIAs varies depending on the application. Inventory or monitoring programs that focus on condition across large areas, with an emphasis on statistical design, often rely on a point based sampling approach (e.g. 0.5 ha AA). In this case, the overall occurrence size is not used to evaluate the assessment area, since it is predetermined by the sampling protocol. Conversely, programs that focus on assessing individual polygons, more typically consider the size of the occurrence as important to its overall integrity. Size does interact with landscape context, such that small occurrences embedded in entirely natural landscapes do not, necessarily, have less ecological integrity than a larger example in the same landscape. Conversely, a large occurrence in a fragmented landscape is likely to be more buffered from landscape stressors than a small one in a similarly fragmented landscape. Thus, a scorecard should give careful consideration to the appropriate manner in which to score size, taking into account this suite of contextual factors.

SIZ1 Comparative Size (Patch Type)

Definition: A measure of the current absolute size (ha) of the entire ecosystem occurrence polygon. The metric is assessed either with respect to its comparative size based on size distribution (Table 31) OR expected patch-type sizes for the type across its range (Table 32).

Background: This metric accounts for one aspect of the size of specific occurrences of an ecosystem. Assessors are sometimes hesitant to use patch size as part of an EIA out of concern that a small, high quality example will be down-ranked unnecessarily. We address these concerns, to a degree, by providing an absolute patch-type scale, so that types that typically occur as small patches (e.g. mesic meadows) are scored differently than types that may occur over large, extensive areas (e.g., many forests).

Apply To: All EIA modules and AA sizes. For large AAs, this is scored for the entire assessment area, not individual assessment points.

Measurement Protocol:

(1) Determine Spatial Size. It is important to know the spatial pattern typical of the ecosystem being assessed. This information is found in the Ecological System descriptions in Rocchio & Crawford (2015) and generalized in Table 1.

(2) Rate Size As Informed by Patch Type. Use Table 32 to assign a Spatial Pattern Size Metric Rating based on the ecosystem's patch type. Compare this to the Comparative Size Metric Rating from Table 31. Essentially, the rating from Table 32 is the same as Table 31.

NOTE: For large-patch and matrix patch types, this measure is made over the entire extent of the AA, not individual assessment points within the AA.

For fragmented occurrences made up of several disjunct AAs, the Comparative Size Metric is scored based on the aggregate of all AAs AND the single largest one. If these are different, assign a range rating (e.g. if the aggregate results in a 'B' rating but the largest patch would only receive a 'C' rating on its own, the resulting rating is 'BC'; if they both come out as 'B', then the overall score is also 'B'.

Table 31. Comparative Size Metric Rating

Metric Rating	*Comparative Size: ALL Types*
EXCELLENT (A)	Very large size compared to other examples of the same type, based on current and historical spatial patterns (and meeting the requirements for all, or almost all, of the area-sensitive indicator species dependent on the system, if within range)
GOOD (B)	Large size compared to other examples of the same type, based on current and historical spatial patterns (and not meeting the requirements for some of the area-sensitive indicator species; i.e., they are likely to be absent, if within range[1]).
FAIR (C)	Medium to small size compared to other examples of the same type, based on current and historical spatial patterns (and not meeting the requirements for several to many of the area-sensitive indicator species, if within range[1]).
POOR (D)	Small to very small size, based on current and historical spatial patterns (and not meeting the requirements for most to all area-sensitive indicator species, if within range[1]).

[1] If known, record the area-dependent species that are missing.

Table 32. Spatial Pattern Size Metric Rating: Area by Spatial Pattern of Type. Consult Rocchio & Crawford (2015) to determine the patch type of the AA's Ecological System.

Metric Rating	*COMPARATIVE SIZE BY PATCH TYPE (hectares)*		
Spatial Pattern Type	Matrix (ha)	Large Patch (ha)	Small Patch (ha)
EXCELLENT (A)	> 5,000	> 125	> 10
GOOD (B)	500-5,000	25-125	2-10
FAIR (C)	100-500	5-25	0.5-2
POOR (D)	< 100	< 5	0.5
Metric Rating	*COMPARATIVE SIZE BY PATCH TYPE (acres)*		

Spatial Pattern Type	Matrix (ac)	Large Patch (ac)	Small Patch (ac)
EXCELLENT (A)	> 12,500	> 300	> 25
GOOD (B)	1,250-12,500	60-300	5-25
FAIR (C)	250-1,250	12-60	1-5
POOR (D)	< 250	< 12	1

SIZ2 Change in Size (optional)

Definition: A measure of the current size of the occurrence relative to its historical extent.

Background: This metric is one aspect of the size of specific occurrences of an ecosystem type. The metric assesses the proportion of the AA that has been converted or destroyed compared to its original extent.

Apply To: *Required* for small AAs of large-patch/matrix ecosystem targets. Optional for all other small AAs.

Measurement Protocol: This metric only applies to small AA sizes. Relative size can be measured in GIS using aerial photographs, orthophoto quads, or other data layers and is calculated as follows:

Change in Size = Current Size / Historical Size * 100

Field assessments of current size may be required since it can be difficult to discern the historical area of the occurrence from remotely sensed data. However, use of old aerial photographs may also be helpful, as they may show the historical extent of an occurrence. Relative size can also be estimated in the field using 7.5 minute topographic quads, NPS Vegetation maps, or a global positioning system. The definition of the "historical" timeframe will vary by region, but generally refers to the intensive Euro-American settlement that began in the 1600s in the eastern United States and extended westward into the 1800s. If the historical time frame is unclear, use a minimum of a 50-year time period--long enough to ensure that the effects of area loss are well-established and the occurrence has essentially adjusted to the change in size. Assign the rating based on Table 33.

Table 33. Change in Size Metric Rating.

Metric Rating	*Change in Size: Small AA Sizes*
EXCELLENT (A)	Occurrence is at, or only minimally reduced[1] (< 5%) from its original, natural extent. See note below for interpretation of "reduction."
GOOD (B)	Occurrence is only somewhat reduced (5-10%) from its original natural extent.
FAIR (C)	Occurrence is modestly reduced (10-30%) from its original natural extent.

POOR (D)	Occurrence is substantially reduced (> 30%) from its original natural extent.

[1]Note: Reduction in size for metric ratings A-D can include conversion or disturbance (e.g., development, changes caused by recent cutting, etc.). Assigning a metric rating depends on the degree of reduction.

4.0 Calculate EIA Score and Determine Element Occurrence Status.

4.1 Ecological Integrity Assessment Scorecard

The major components of the EIA include three primary rank factors (landscape context, on-site condition, and size) which are subdivided into five major ecological factors of landscape, edge, vegetation, soils, and size. Together these are the components that capture the structure, composition, processes, and connectivity of an occurrence. Whether one needs to roll up scores is dependent on the project objective. Land managers may only be interested in the metric scores, as they provide insight into management needs, goals, and measures of success. On the other hand, if the goal is to compare or prioritize sites for conservation, restoration, or management actions, then an overall EIA score/rank may be needed. Primary and major ecological factor scores/ranks can be helpful for understanding current status of primary ecological drivers. Details on the scorecard are provided in (Faber-Langendoen et al., 2016b).

Landscape context metrics address the "outer workings" while on-site condition metrics measure the "inner workings" of an ecosystem. A third primary rank factor, the size of an ecosystem patch or occurrence, helps to characterize patterns of diversity, area-dependent species, and resistance to stressors. Addressing all of these characteristics and processes will contribute not only to understanding the current levels of ecological integrity, but to the resilience of the ecosystem in the face of climate change and other global stressors.

A point-based approach is used to facilitate integration of metrics into an overall rating. Undue emphasis should not be placed on numerical scoring--it is the overall rating that matters. Although metric ratings and scores are primarily based on a four-part scale (Table 8), when two or more metrics are used to score a major ecological factor, a seven-part scale (A+, A-, B+, B-, C+, C-, D) can be informative. A "rounded" four-part scale (A, B, C, D) can still be applied (Table 34).

Table 34. Ratings and Points for Ecological Integrity, Primary Rank Factors, and Major Ecological Factors.

EIA and Factor Rating*	*7 Part Scale*	*Metric Rating*	*4 Part Scale*
A+	3.8 - 4.00	A (Excellent)	3.5 - 4.0
A-	3.5 - 3.79		
B+	3.0 - 3.49	B (Good)	2.5 - 3.49
B-	2.5 - 2.99		
C+	2.0 - 2.49	C (Fair)	1.5 - 2.49
C-	1.5 - 1.99		
D	1 - 1.49	D (Poor)	1.0 - 1.49

*This scale is applied to the overall EIA, as well as Primary Rank Factors and Major Ecological Factors.

4.2 Calculate Major Ecological Factor (MEF) Scores and Ratings

Below are instructions on how to calculate each Major Ecological Factor score. Once scores are calculated, their associated ratings can be found Table 35.

Table 35. Conversion of Major Ecological Factor Scores/Ratings.

Score/Rating Conversions for Major Ecological Factors							
Rank	A+	A-	B+	B-	C+	C-	D
Score	3.8 - 4.00	3.5 - 3.79	3.0 - 3.49	2.5 - 2.99	2.0 - 2.49	1.5 - 1.99	1 - 1.49

4.2.1 Landscape Context MEF Score/Rating

To calculate the Landscape Context MEF score, take the average of LAN1 and LAN2 metrics. Enter the score and associated rating on the field form.

4.2.2 Edge MEF Score/Rating

Small AA sizes: The Edge MEF score is calculated by first taking the geometric mean of EDG1 and EDG2 scores. Then the geometric mean of that result and EDG3 is used as the Edge MEF score. A geometric mean gives greater weight to the lower of the two values. Enter the score and associated rating on the field form.

Large AA sizes: The Edge MEF score is calculated by taking the geometric mean of EDG1 and EDG2 scores. A geometric mean gives greater weight to the lower of the two values. Enter the score and associated rating on the field form.

4.2.3 Vegetation MEF Score/Rating

Vegetation MEF score is calculated by taking the average of VEG1+VEG2+VEG3+VEG4+VEG5 (if scored)+VEG6 (if scored). Enter the score and associated rating on the field form.

4.2.4 Soils MEF Score/Rating

The Soil MEF score is simply the score for SOI1. Enter the score and associated rating on the field form.

4.2.5 Size MEF Score/Rating

The Size MEF score is either simply the score for SIZ1 or, if also using SIZ2, then the average of SIZ1 and SIZ2. Enter the score and associated rating on the field form.

4.3 Calculate Primary Factor Scores

Below are instructions on how to calculate each Primary Factor score. Once scores are calculated, their associated ratings can be found in Table 36.

Table 36. Conversion of Primary Factor Scores/Ratings.

Score/Rating Conversions for Primary Factors							
Rank	A+	A-	B+	B-	C+	C-	D
Score	3.8 - 4.00	3.5 - 3.79	3.0 - 3.49	2.5 - 2.99	2.0 - 2.49	1.5 - 1.99	1 - 1.49

4.3.1 Landscape Context Primary Factor Score/Rating

The Landscape Context Primary Factor score is calculated by the following formulas, depending on spatial pattern type of the Ecological System:

Matrix: (Edge MEF score*0.33) + (Landscape Context MEF score*0.67)

Large-Patch: (Edge MEF score*0.50) + (Landscape Context MEF score*0.50)

Small-Patch: (Edge MEF score*0.67) + (Landscape Context MEF score*0.33)

Enter the score and associated rating on the field form.

4.3.2 Condition Primary Factor Score/Rating

The Condition Primary Factor score is calculated by the following formula: (Vegetation MEF score*0.85) + (Soil MEF score*0.15). Enter the score and associated rating on the field form.

4.3.3 Size Primary Factor Score/Rating

The Size Primary Factor score is equivalent to the Size MEF score. Enter the score and associated rating on the field form.

4.4 Calculate Overall Ecological Integrity Assessment Score/Rating

The overall Ecological Integrity Assessment (EIA) score is calculated using only Landscape Context and Condition Primary Factor scores with the following formulas (NatureServe, 2002), depending on spatial pattern type of the Ecological System:

Matrix/Large-Patch: (Condition Primary Factor score*0.55) + (Landscape Context Primary Factor score*0.45).

Small-Patch: (Condition Primary Factor score*0.70) + (Landscape Context Primary Factor score*0.30).

The associated rating for the score is found in Table 37. Enter the score and associated rating on the field form.

Table 37. Conversion of Overall Ecological Integrity Assessment Scores/Ratings.

Score/Rating Conversions for Overall Ecological Integrity							
Rank	A+	A-	B+	B-	C+	C-	D
Score	3.8 - 4.00	3.5 - 3.79	3.0 - 3.49	2.5 - 2.99	2.0 - 2.49	1.5 - 1.99	1 - 1.49

Size is not used for the EIA score, as the role of patch size in assessing ecological integrity is not as straightforward as landscape context and condition. For some ecosystem types, patch size can vary widely for entirely natural reasons (e.g., a forest type may have very large occurrences on rolling landscapes, and be restricted in other landscapes to small occurrences on north slopes or ravines). Thus, smaller sites are not necessarily a result of degradation in ecological integrity. On the other hand, size overlaps with landscape context as a factor, where the more fragmented the landscape surrounding an occurrence is, the more size becomes important in reducing edge effects or buffering the overall occurrence.

Thus, while from an EIA rating perspective, we can develop vegetation, soil, and landscape metric ratings based on ecological considerations (e.g., we can establish the ecological criteria for which natural edges are effective), it is harder to do so for size. Instead, Size is used as an additional factor to help prioritize sites for conservation actions (see below).

4.5 Calculate The Element Occurrence Rank

Ecological Integrity Assessment (EIA) scores and Element Occurrence Ranks (EORANKS) are closely related. The EIA score provides a succinct assessment of the current ecological condition and landscape context of an occurrence. For conservation purposes, we often want to do more than that; namely, we want to establish its conservation value. The Element Occurrence (EO) is a core part of Natural Heritage Methodology and is defined as follows:

> *An **Element Occurrence** (EO) is an area of land and/or water in which a species or ecosystem (natural community, vegetation type or Ecological System) element is, or was, present. An EO should have practical conservation value for the Element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For ecosystem types ("elements"), the EO may represent a single stand or patch or a cluster of stands or patches of an ecosystem.* (NatureServe, 2002).

For the EORANK approach, EIAs are foundational, but more is needed to determine the practical conservation value for an ecosystem. In particular, size plays a more substantial role in the EORANK process than in other applications of EIAs. This is because, for many conservation purposes, larger observations are considered more important and more likely to retain their integrity than smaller observations. For some types, diversity of animals or plants may be higher in larger occurrences than in smaller occurrences that are otherwise similar. Larger occurrences often have more microhabitat features and are more resistant to stressors such as invasion by exotics, because they buffer their own interior portions. Thus, size can serve as a readily measured proxy for some ecological processes and for the diversity of interdependent assemblages of plants and animals. Even here, caution is needed, for although size helps identify higher diversity sites, higher diversity *per se* is not always tied to ecological integrity (i.e., sites vary naturally with respect to levels of diversity and size).

To calculate EORANK, points are added to the EIA score based on the plant community's patch size (Table 32) and Size Primary Factor rating (Table 38). The associated rating for the score is found in Table 39. Enter the score and associated rating on the field form.

Table 38. Point Contribution of Size Primary Factor Score.

Size Primary Factor Rating	Small Patch	Large Patch	Matrix
A = Size meets A ranked rating	+ 0.75	+ 1.0	+1.5
B = Size meets B ranked rating	+ 0.25	+ 0.33	+0.5
C = Size meets C ranked rating	- 0.25	- 0.33	-0.5
D = Size meets D ranked rating	- 0.75	-1.0	-1.5

Table 39. Conversion of EORANK Scores/Ratings.

Score/Rating Conversions for EORANK							
Rank	A+	A-	B+	B-	C+	C-	D
Score	3.8 - 4.00	3.5 - 3.79	3.0 - 3.49	2.5 - 2.99	2.0 - 2.49	1.5 - 1.99	1 - 1.49

4.6 Determine Element Occurrence Status

Using the conservation status rank and the EORANK of the AA, refer to Table 40 to determine whether the AA meets Element Occurrence criteria. If it does, please submit documentation of the occurrence to the Washington Natural Heritage Program for inclusion in our database.

Table 40. Decision Matrix to Determine Ecosystem Element Occurrences.

Global / State Conservation Status Rank Combination	Ecological Integrity Assessment Rank			
	A (+ or -) Excellent Integrity	B (+ or -) Good Integrity	C (+ or -) Fair Integrity	D (+ or -) Poor Integrity
G1S1, G2S1, GNRS1, GUS1				
G2S2, GNRS2, G3S1, G3S2, GUS2				
GUS3, GNRS3, G3S3, G4S1, G4S2, G5S1, G5S2, any SNR				
G4S3, G4S4, G5S3, G5S4, G5S5, GNRS4, GNRS5, GUS4, GUS5				
Red Shading = Element Occurrence				

5.0 Stressor Checklist

A stressor is an anthropogenic perturbation within the AA or surrounding landscape that can negatively affect the condition and function of the occurrence. Stressors are *direct threats* and are further defined as "the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes" (NatureServe, 2017). Identifying stressors within the AA or its buffer can help determine causes of the AA's degradation. Stressors may be characterized in terms of ***scope*** and ***severity***. Scope is defined as the proportion of the AA that can reasonably be expected to be affected by the stressor with continuation of current circumstances and trends. Severity is the degree of degradation within the scope from the stressor, which can reasonably be expected with continuation of current circumstances and trends.

Step 1 Rate Scope and Severity of Stressors: Stressors are rated if they are observed or inferred to occur. They are not assessed if they are projected to occur in the near term, but have not yet been observed. Record and estimate the scope and severity of applicable stressors in the AA or its edge (Table 41). Things to consider when filling out the form:

- Stressor checklists must be completed for all categories (Buffer, Vegetation, and Soils/Substrate). The hydrology category has been omitted from initial drafts of upland assessments.
- Buffer perimeter is the entire perimeter **around the AA,** out to a distance of 100 m. Rely on imagery in combination with field observations.
- Assess edge perimeter stressors and their effects within the buffer perimeter itself (**NOT how buffer stressors may impact the AA**).
- Stressors for Vegetation and Soils are assessed across the AA.
- Some stressors may overlap (e.g., 10 [low impact recreation] may overlap with 26 [indirect soil disturbance]); choose the one with the highest impact and note overlap.
- Stressors are rated if they are observed or inferred to occur in the present (i.e., within a 10 year timeframe), **or** occurred anytime in the past with effects that persist into the present.

Table 41. Stressor Scoring Categories.

Assess for up to next 20 yrs.	Threat Scope (% of AA affected)	Assess for up to next 20 yrs.	Threat Severity within the Scope (degree of degradation of AA)
1 = Small	Affects a small (1-10%) proportion	1 = Slight	Likely to only slightly degrade/reduce
2 = Restricted	Affects some (11-30%)	2 = Moderate	Likely to moderately degrade/reduce

3 = Large	Affects much (31-70%)	3 = Serious	Likely to seriously degrade/reduce
4 = Pervasive	Affects most or (71-100%)	4 = Extreme	Likely to extremely degrade/destroy or eliminate

Step 2 Determine Impact Rating of Each Stressor: The impact rating of each stressor is based on the combination of its scope and severity score (Table 42). Enter the corresponding impact rating score in the "Impact" cell for each stressor. If no stressors are present or their impact is presumed to be minimal, check the appropriate box on the stressor form.

Table 42. Stressor Impact Ratings.

Stressor Impact Calculator		Scope			
		Pervasive	Large	Restricted	Small
Severity	Extreme	Very High = 10	High = 7	Medium = 4	Low = 1
	Serious	High = 7	High = 7	Medium = 4	Low = 1
	Moderate	Medium = 4	Medium = 4	Low = 1	Low = 1
	Slight	Low = 1	Low = 1	Low = 1	Low = 1

Step 3 Determine Overall Stressor Impact Rating for Stressor Categories: For each category (Buffer, Vegetation, and Soils), sum the total impact scores and enter the corresponding impact rating and point value (Table 43) in the appropriate cell at the bottom of the field form. For example, if the summed impact scores across all stressors in the Buffer category is 8, then the impact rating is "High" and has a corresponding point value of 3.

Table 43. Conversion of Total Impact Scores to Stressor Category Ratings/Points.

STRESSOR RATING Summary for Categories	Sum of Stressor Impact Scores	Stressor Rating	Pts
1 or more Very High, **OR** 2 or more High, **OR** 1 High + 1 or more Medium **OR** 3 or more Medium	10+	Very High	4
1 High, **OR** 2 Medium **OR** 1 Medium + 3 or more Low	7 – 9.9	High	3
1 Medium + 1-2 Low **OR** 4 -6 Low	4 – 6.9	Medium	2
1 to 3 Low	1 – 3.9	Low	1
0 stressors	0 – 0.9	Absent	0

Step 4 Determine Human Stressor Impact (HSI) Rating for AA: Next, using the algorithms on the field form, calculate overall impact scores based on each stressor category's impact points. HSI scores are calculated for three different metrics: (1) Total HSI (all stressor categories are used); (2) Onsite HSI (Buffer stressors are excluded); and (3) Abiotic HSI (Vegetation stressors are excluded). HSI scores can be converted to a rating using Table 44.

Table 44. Conversion of Human Stressor Index (HSI) Scores to Ratings.

HSI Score	HSI Site Rating
3.5-4.0	Very High
2.5-3.4	High
1.5-2.4	Medium
0.5-1.4	Low
0.0-0.4	Absent

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Appendix A. Diagnostic Species and Common Increasers, Decreasers, and Invasive Plants of Washington's Ecological Systems (DRAFT- In Progress)

Table A-1 presents diagnostic species for each Ecological System known to occur in Washington. These species help define the system and should be found in most occurrences with high integrity. They are generally *not* exclusive to any one system, however. Additionally, Table A-1 provides example increaser, decreaser, and invasive species for each Ecological System. Increaser and decreaser species may also be accompanied by the stressor generally responsible for their increase or decrease. These lists are not comprehensive and should be readily modified using professional judgment and local knowledge. In addition, you can use the Floristic Quality Assessment (FQA) calculators on the WNHP website (http://www.dnr.wa.gov/NHP-FQA) to help identify increasers (c-values ≤ 3) and decreasers (c-values ≥ 7).

Table A-1. Diagnostic Species and Common Increasers, Decreasers, and Invasive Plant of Washington's Ecological Systems.

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Columbia Basin Foothill and Canyon Dry Grassland (Campbell, 1962; Daubenmire, 1970; Tisdale, 1986; Johnson, 1998; Rocchio & Crawford, 2013, 2015)	Pseudoroegneria spicata Festuca idahoensis Koeleria macrantha Poa secunda Aristida purpurea var. longiseta Balsamorhiza sagittata Sporobulus cryptandrus Opuntia polyacantha	Achillea millefolium Antennaria luzuloides (grazing) Aristida purpurea var. longiseta Arnica sororia Astragalus inflexus Balsamorhiza sagittata (grazing) Collinsia parviflora Danthonia unispicata (grazing) Epilobium brachycarpum (=E. paniculatum) Ericameria nauseosa Erigeron pumilis Gutierrezia sarothrae (grazing) Lithophragma glabrum (=L. bulbifera) Lagophylla ramosissima Madia glomerata (grazing) Microsteris gracilis Penstemon deustus Stellaria nitens Tonella floribunda (grazing)	Poa secunda (grazing) Festuca idahoensis (grazing)	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Poa bulbosa Centaurea spp. Hypericum perforatum Ventenata dubia
Columbia Basin Palouse Prairie	Pseudoroegneria spicata Festuca idahoensis	Achillea millefolium	Astragalus spaldingii Calochortus elegans	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum)

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
(Daubenmire, 1970; Johnson, 1998; Parish et al., 1999; Rocchio & Crawford, 2015)	Koeleria macrantha Poa secunda Rosa nutkana Eriogonum spp. Symphoricarpos albus	Claytonia rubra ssp. depressa (Montia perfoliata) Clematis ligusticifolia Collinsia parviflora Danthonia unispicata (grazing) Epilobium brachycarpum (=E. paniculatum) Erigeron corymbosus Eriogonum heracleoides (grazing) Geum triflorum Iris missouriensis Koeleria macrantha Lagophylla ramosissima Lithophragma glabrum (=L. bulbifera) Microsteris gracilis Montia linearis Myosurus apetalus (=M. aristatus) Olsynium douglasii var. inflatum (=Sisyrinchium inflatum) Stellaria nitens Tonella floribunda (grazing)	Festuca idahoensis Geranium viscosissimum Geum triflorum Helianthella uniflora Hieracium albertinum Potentilla gracilis Triteleia grandiflora var. grandiflora (=Brodiaea douglasii) Rosa nutkana (grazing) Symphoricarpos albus (grazing)	Ventenata dubia Poa bulbosa Poa pratensis Hypericum perforatum Potentilla recta Euphorbia virgata Centaurea spp.
Columbia Plateau Low Sagebrush Steppe (Daubenmire, 1970; Crowe & Clausnitzer, 1997; Johnson, 1998; Rocchio & Crawford, 2015)	Artemisia arbuscula ssp. arbuscula Artemisia rigida Eriogonum spp. Festuca idahoensis Poa secunda Pseudoroegneria spicata Koeleria macrantha	Achillea millefolium Antennaria luzuloides (grazing) Artemisia arbuscula ssp. arbuscula (grazing) Balsamorhiza sagittata (grazing) Ericameria nauseosa (grazing) Eriogonum heracleoides (grazing) Lomatium nudicaule Madia glomerata (grazing) Phlox sp. Trifolium macrocephalum Elymus elymoides (= Sitanion hystrix)	Agoseris retrorsa Frasera albicaulis Trifolium macrocephalum	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Poa bulbosa Centaurea spp. Linaria dalmatica ssp. dalmatica
Columbia Plateau Scabland Shrubland	Artemisia rigida Eriogonum (compositum, douglasii, sphaerocephalum, strictum, thymoides)	Achillea millefolium Balsamorhiza (serrata, incana) Danthonia unispicata (grazing)	Trifolium macrocephalum	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Poa bulbosa

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
(Daubenmire, 1970; Johnson, 1998; Rocchio & Crawford, 2015)	Stenotus stenophyllus Poa secunda	Elymus elymoides (= Sitanion hystrix) Lomatium nudicaule Phlox sp. Trifolium macrocephalum (surface disturbance)		Centaurea spp. Linaria dalmatica ssp. dalmatica
Columbia Plateau Steppe and Grassland (Daubenmire, 1970; Crowe & Clausnitzer, 1997; Johnson, 1998; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Achnatherum hymenoides Achnatherum thurberianum Elymus elymoides (= Sitanion hystrix) Elymus lanceolatus ssp. lanceolatus Hesperostipa comata Festuca idahoensis Koeleria macrantha Poa secunda Pseudoroegneria spicata	Achnatherum hymenoides Antennaria luzuloides (grazing) Artemisia tridenta ssp. wyomingensis (grazing, lack of fire) Balsamorhiza (sagittata, serrata, incana) Carex douglasii (grazing, soil compaction) Chrysothamnus viscidiflorus Elymus elymoides (= Sitanion hystrix) Ericameria nauseosa (grazing) Eriogonum heracleoides (grazing) Madia glomerata (grazing) Tetradymia spp.	Agoseris retrorsa Poa cusickii ssp. cusickii Trifolium macrocephalum	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Poa bulbosa Centaurea spp. Linaria dalmatica ssp. dalmatica
Columbia Plateau Western Juniper Woodland and Savanna (Daubenmire, 1970; Crowe & Clausnitzer, 1997; Johnson, 1998; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Juniperus occidentalis Artemisia tridentata susbsp. Tridentata? Or wyomingensis?	Artemisia tridenta ssp. wyomingensis (grazing, lack of fire) Balsamorhiza sagittata (grazing) Ericameria nauseosa (grazing) Penstemon deustus (grazing) Penstemon venustus (grazing) Senecio integerrimus var. exaltatus (grazing)	Carex (cordillerana, backii) (grazing)	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Poa bulbosa Centaurea spp.
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland (John & Tart, 1986; Johnson, 1988, 2004; Lillybridge et al., 1995;	Pseudotsuga menziesii Abies grandis Tsuga heterophylla Thuja plicata Pinus contorta Pinus monticola Larix occidentalis	Elymus glaucus Lathyrus pauciflorus (grazing) Linnaea borealis (logging) Luina hypoleuca (grazing) Pteridium aquilinum Spiraea betulifolia (grazing, logging, soil disturbance)	Achlys triphylla Arnica lanceolata Carex bolanderi Corallorhiza maculata Listera cordata Listera caurina	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Tannas, 2001; Rocchio & Crawford, 2013, 2015)	Acer circinatum Achlys triphylla Symphoricarpos hesperius Mahonia nervosa	Symphoricarpos hesperius Thalictrum occidentale (soil disturbance) Urtica dioica	Melica subulata var. subulata Nothochelone nemorosa	
East Cascades Oak-Ponderosa Pine Forest and Woodland (John & Tart, 1986; Johnson, 1988; Lillybridge et al., 1995; Crowe & Clausnitzer, 1997; Tannas, 2001; Rocchio & Crawford, 2013, 2015)	Quercus garryana Pinus ponderosa Pseudotsuga menziesii Calamagrostis rubescens Festuca idahoensis Carex geyeri Carex rossii Carex inops Corylus cornuta Elymus glaucus Pseudoroegneria spicata Symphoricarpos albus	Achillea millifolium Carex rossii (grazing, soil disturbance) Collomia grandiflora Elymus glaucus Lathyrus lanszwertii var. lanszwertii Lupinus arbustus Potentilla gracilis (grazing) Rosa woodsii var. ultramontana	Festuca idahoensis (grazing) Frasera albicaulis Poa cusickii ssp. cusickii	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Cynosurus echinata Poa bulbosa
Inter-Mountain Basins Active and Stabilized Dune (Daubenmire, 1970; Hallock et al., 2007; Rocchio & Crawford, 2015)	Psoralidium lanceolatum Achnatherum hymenoides Corispermum sp. Rumex venosus Phacelia hastata Elymus lanceolatus Ericameria nauseosa Chrysothamnus viscidiflorus Purshia tridentata Artemisia tridentata ssp. wyomingensis	Achnatherum hymenoides Chrysothamnus viscidiflorus	Rumex venosus	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Salsola kali Sisymbrium altissimum
Inter-Mountain Basins Big Sagebrush Steppe (Daubenmire, 1970; Johnson, 1998; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Artemisia tridentata ssp. tridentata Artemisia tridentata ssp. xericensis Artemisia tridentata ssp. wyomingensis Artemisia tripartita ssp. tripartita Purshia tridentata Pseudoroegneria spicata Poa secunda Poa cusickii Koeleria macrantha	Antennaria luzuloides (grazing) Balsamorhiza sagittata (grazing) Carex douglasii (grazing, soil compaction) Ericameria nauseosa (grazing) Eriogonum heracleoides (grazing) Hesperostipa comata Lomatium nudicaule Madia glomerata (grazing) Potentilla gracilis	Carex vallicola (grazing) Poa cusickii ssp. cusickii	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Linaria dalmatica ssp. dalmatica Sisymbrium altissimum

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Hesperostipa comata Achnatherum thurberiana			
Inter-Mountain Basins Cliff and Canyon (Daubenmire, 1970; Rocchio & Crawford, 2013, 2015)	Amelanchier spp. Celtis reticulata Rhus glabra Juniperus spp. Artemisia tridentata Purshia tridentata Cercocarpus ledifolius	-	Delphinium nuttallii	-
Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland (Daubenmire, 1970; Johnson, 1998; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Cercocarpus ledifolius Pseudoroegneria spicata Festuca idahoensis	Balsamorhiza sagittata (grazing) Penstemon deustus (grazing) Penstemon venustus (grazing) Senecio integerrimus var. exaltatus (grazing)	Carex (cordillerana, backii) (grazing)	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Linaria dalmatica ssp. dalmatica Sisymbrium altissimum Centaurea spp.
Inter-Mountain Basins Montane Sagebrush Steppe (Daubenmire, 1970; Johnson, 1988, 1998, 2004; Crowe & Clausnitzer, 1997; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Artemisia tridentata ssp. vaseyana Artemisia tridentata ssp. spiciformis (= A. spiciformis). Purshia tridentata Symphoricarpos spp. Amelanchier spp. Ericameria nauseosa Ribes cereum Chrysothamnus viscidiflorus Festuca idahoensis Festuca campestris	Antennaria luzuloides (grazing) Artemisia tridentata ssp. vaseyana (grazing) Bromus carinatus (grazing, soil disturbance) Chrysothamnus viscidiflorus Elymus elymoides (= Sitanion hystrix) Ericameria nauseosa (grazing) Eriogonum heracleoides (grazing) Lomatium nudicaule Madia glomerata (grazing) Potentilla gracilis Senecio integerrimus var. exaltatus (grazing)	Carex petasata (grazing) Carex vallicola (grazing) Festuca campestris	Poa pratensis Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum)
Inter-Mountain Basins Semi-Desert Shrub-Steppe (Daubenmire, 1970; Crowe & Clausnitzer,	Grayia spinosa Krascheninnikovia lanata Ericameria nauseosa Artemisia tridentata Achnatherum hymenoides Achnatherum thurberiana	Artemisia tridentata ssp. wyomingensis (grazing) Carex douglasii (grazing, soil compaction) Elymus elymoides (= Sitanion hystrix)	Atriplex canescens Krascheninnikovia lanata	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Linaria dalmatica ssp. dalmatica Salsola kali Sisymbrium altissimum

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
1997; Wilson et al., 2014; Rocchio & Crawford, 2015)	Elymus elymoides (= Sitanion hystrix) Poa secunda Sporobolus airoides Hesperostipa comata			
North Pacific Active Volcanic Rock and Cinder Land	n/a	n/a	n/a	n/a
North Pacific Alpine and Subalpine Bedrock and Scree (Pojar & MacKinnon, 1994; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Agrostis variabilis Artemisia ludoviciana Athyrium distentifolium (= A. americanum) Cryptogramma acrostichoides Lomatium martindalei Luetkea pectinata Luina hypoleuca Luzula piperi Micranthes tolmiei Oxyria digyna Penstemon davidsonii var. davidsonii Penstemon rupicola Phacelia hastata	Polygonum minimum	Agrostis variabilis Aspidotis densa Asplenium viride Athyrium distentifolium (= A. americanum) Campanula piperi Carex breweri Cryptogramma acrostichoides Elmera racemosa Luina hypoleuca Oxyria digyna Penstemon davidsonii var. davidsonii Penstemon rupicola Senecio neowebsteri Silene acaulis	n/a
North Pacific Alpine and Subalpine Dry Grassland (Douglas & Bliss, 1977; Johnson, 1988, 2004; Crowe & Clausnitzer, 1997; Tannas, 2001; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Arenaria capillaris Carex spectabilis Carex hoodii Eucephalus (engelmannii, ledophyllus) Festuca idahoensis Festuca viridula Festuca roemeri Ligusticum grayi Lupinus latifolius ssp. subalpinus Luetkea pectinata Phlox diffusa Polygonum bistortoides Potentilla flabellifolia	Antennaria lanata Lupinus spp. Achnatherum occidentale Carex rossii (grazing, soil disturbance) Elymus glaucus Leptosiphon nuttallii ssp. nuttallii (grazing) Rudbeckia occidentalis Juncus parryi Penstemon sp. Potentilla gracilis (grazing) Cirsium edule Phacelia hastata Polygonum minimum	Anemone occidentalis Carex hoodii (grazing) Delphinium glareosum Festuca viridula Ligusticum grayi Podagrostis humilis (= Agrostis humilis) Trisetum spicatum (grazing)	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
North Pacific Avalanche Chute Shrubland	Acer circinatum Alnus viridis ssp. sinuata Rubus parviflorus Chamaecyparis nootkatensis Prunus virginiana Amelanchier alnifolia Vaccinium membranaceum	n/a	Polystichum andersonii	-
North Pacific Broadleaf Landslide Forest and Shrubland (Tannas, 2001; Chappell, 2006a; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Alnus rubra Acer macrophyllum Rubus spectabilis Rubus parviflorus Ribes bracteosum Oplopanax horridus Polystichum munitum	Elymus glaucus Geum macrophyllum Pteridium aquilinum Rubus ursinus Urtica dioica	Polystichum andersonii Woodwardia fimbriata	Hedera helix Rubus bifrons (= R. discolor, R. armeniacus) Geranium robertianum Cytisus scoparium Ranunculus repens
North Pacific Coastal Cliff and Bluff (Chappell, 2006b; Rocchio & Crawford, 2013, 2015)	Calamagrostis nutkaensis Equisetum telmateia Festuca rubra Gaultheria shallon Grindelia hirsutula (= G. stricta, nana) Vicia nigra ssp. gigantea	Achillea millefolium Epilobium ciliatum ssp. ciliatum Solidago canadensis	-	Bromus (diandrus, hordeaceus) Cirsium spp. Cytisus scoparius Conium maculatum Holcus lanatus Ulex europaeus
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field, or Meadow (Johnson, 1998; Tannas, 2001; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Cassiope mertensiana Phyllodoce empetriformis Phyllodoce glanduliflora Luetkea pectinata Saxifraga tolmiei Carex (breweri, capitata, nardina, proposita, scirpoidea var. pseudoscirpoidea, spectabilis) Dasiphora fruticosa Empetrum nigrum Erigeron aureus Eriogonum pyrolifolium Festuca roemeri Lupinus latifolius ssp. subalpinus Lupinus lepidus var. lobbii (=L. sellulus)	Antennaria lanata Danthonia intermedia (grazing) Eriogonum pyrolifolium Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling) Phleum alpinum (grazing)	Agoseris aurantiaca var. aurantiaca Agrostis variabilis Anemone occidentalis Antennaria alpina Carex breweri Carex heteroneura Carex nardina Carex preslii Carex proposita (recreation, trampling) Carex scirpoidea var. pseudoscirpoidea Empetrum nigrum (trampling) Festuca viridula Luzula piperi Packera streptanthifolia	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Luzula piperi Oreostemma alpigenum Packera cana Phlox diffusa Salix cascadensis Vaccinium deliciosum		Phyllodoce empetriformis (trampling) Phyllodoce glanduliflora (trampling) Podagrostis humilis (= Agrostis humilis) Salix cascadensis Saxifraga tolmiei Campanula piperi Salix nivalis Trisetum spicatum (grazing) Vahlodea atropurpurea Veronica cusickii	
North Pacific Dry Douglas-fir Forest and Woodland (John & Tart, 1986; Tannas, 2001; Chappell, 2006a; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Pseudotsuga menziesii Arbutus menziesii Pinus contorta var. contorta Acer macrophyllum Abies grandis Corylus cornuta var. californica Holodiscus discolor Lonicera hispidula Mahonia nervosa Rosa gymnocarpa Rubus ursinus Symphoricarpos albus Vaccinium ovatum Festuca occidentalis Pteridium aquilinum var. pubescens	Alnus rubra (logging) Elymus glaucus Symphoricarpos albus Polystichum munitum Pteridium aquilinum var. pubescens Rubus ursinus	Kopsiopsis hookeri (= Boschniakia hookeri) Corallorhiza maculata Festuca subuliflora Melica subulata var. subulata	Agrostis capillaris Hedera helix Holcus lanatus Poa pratensis Bromus diandrus (= B. rigidus) Daphne laureola Cynosurus echinatus Festuca arundinacea Hypericum perforatum Ilex aquifolium Cytisus scoparium
North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (Henderson et al., 1989, 1992; Tannas, 2001; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Tsuga heterophylla Abies amabilis Pseudotsuga menziesii Chamaecyparis nootkatensis Abies procera Abies amabilis Achlys triphylla Mahonia nervosa Xerophyllum tenax Vaccinium membranaceum	Alnus rubra Elymus glaucus Geum macrophyllum Pteridium aquilinum Urtica dioica	Achlys triphylla Listera caurina Rhododendron albiflorum	Geranium robertianum

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Vaccinium ovalifolium Rhododendron macrophyllum Rhododendron albiflorum			
North Pacific Herbaceous Bald and Bluff (Tannas, 2001; Chappell, 2006b; Rocchio & Crawford, 2013, 2015)	Festuca roemeri Danthonia californica Achnatherum lemmonii Festuca rubra Koeleria macrantha Camassia quamash Camassia leichtlinii Triteleia hyacinthina Mimulus guttatus Plectritis congesta Lomatium martindalei Allium cernuum Phlox diffusa Arctostaphylos uva-ursi Arctostaphylos nevadensis Juniperus communis	Camassia quamash Cerastium arvense (grazing) Fragaria virginiana (grazing, soil disturbance) Mimulus guttatus	Lomatium martindalei Selaginella wallacei	Cytisus scoparium Hypericum perforatum Hypochaeris radicata Holcus lanatus Chrysanthemum leucanthemum Hieracium pilosella Potentilla recta Centaurea spp. Bromus hordeaceus Agrostis capillaris Anthoxanthum odoratum Poa pratensis Arrhenatherum elatius Taeniatherum caput-medusae Festuca arundinacea Ulex europaeus
North Pacific Hypermaritime Shrub and Herbaceous Headland (Tannas, 2001; Chappell, 2006b; Rocchio & Crawford, 2013, 2015)	Gaultheria shallon Vaccinium ovatum Lonicera involucrata Rubus spectabilis Rubus parviflorus Vaccinium alaskaense Vaccinium ovalifolium Festuca rubra Calamagrostis nutkaensis Elymus glaucus Danthonia californica Bromus sitchensis Solidago canadensis Lomatium martindalei Vicia gigantea Equisetum telmateia Artemisia suksdorfii Pteridium aquilinum Blechnum spicant	Artemisia suksdorfii Calamagrostis nutkaensis Elymus glaucus Solidago canadensis	Lomatium martindalei	Anthoxanthum odoratum Holcus lanatus Dactylis glomerata Ulex europaeus

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
North Pacific Hypermaritime Sitka Spruce Forest (Henderson et al., 1989; Crawford et al., 2009; Rocchio & Crawford, 2015)	Picea sitchensis Tsuga heterophylla Thuja plicata Gaultheria shallon Vaccinium ovatum Maianthemum dilatatum Oxalis oregana Polystichum munitum Dryopteris spp. Blechnum spicant	Acer circinatum Alnus rubra Polystichum munitum Pteridium aquilinum Rubus spectabilis Urtica dioica	Monotropa uniflora	Hedera helix Geranium robertianum Ranunculus repens
North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest (Henderson et al., 1989; Crawford et al., 2009; Rocchio & Crawford, 2015)	Tsuga heterophylla Thuja plicata Gaultheria shallon Vaccinium ovatum Maianthemum dilatatum Oxalis oregana Polystichum munitum Dryopteris spp. Blechnum spicant	Acer circinatum Alnus rubra Polystichum munitum Pteridium aquilinum Rubus spectabilis Urtica dioica	Maianthemum dilatatum Monotropa uniflora	Hedera helix Geranium robertianum Ranunculus repens
North Pacific Maritime Coastal Sand Dune (Wiedemann, 1984; Christy et al., 1998; Rocchio & Crawford, 2015)	Ambrosia chamissonis Abronia latifolia Cakile maritime Cakile edentula Leymus arenarius (= Elymus arenarius) Festuca rubra Leymus mollis Gaultheria shallon Vaccinium ovatum Pinus contorta var. contorta	-	Poa macrantha	Agrostis spp. Ammophila (arenaria, breviligulata) Anthoxanthum odoratum Holcus lanatus Cytisus scoparius Ulex europaeus
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (Chappell, 2006a; Crawford et al., 2009; Rocchio & Crawford, 2015)	Pseudotsuga menziesii Tsuga heterophylla Abies grandis Thuja plicata Acer macrophyllum Gaultheria shallon Mahonia nervosa Rhododendron macrophyllum Linnaea borealis	Alnus rubra Geum macrophyllum Polystichum munitum Pteridium aquilinum Rubus spectabilis Urtica dioica	Achlys triphylla Boschniakia hookeri Corallorhiza maculata Listera cordata Listera caurina Nothochelone nemorosa Polystichum andersonii Pyrola picta	Digitalis purpurea Hedera helix Geranium robertianum Ranunculus repens

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Achlys triphylla Vaccinium ovatum Acer circinatum			
North Pacific Maritime Mesic Subalpine Parkland (Henderson et al., 1989, 1992; Johnson, 1998; Tannas, 2001; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Tsuga mertensiana Abies amabilis Chamaecyparis nootkatensis Abies lasiocarpa Phyllodoce empetriformis Cassiope mertensiana Vaccinium deliciosum Lupinus latifolius ssp. subalpinus Valeriana sitchensis Carex spectabilis Polygonum bistortoides	Elymus glaucus Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling) Lupinus latifolius ssp. subalpinus	Phyllodoce empetriformis (trampling) Elliottia pyroliflora Lycopodium sitchense Sorbus sitchensis var. sitchensis	-
North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (Henderson et al., 1989, 1992; Chappell, 2006a; Crawford et al., 2009; Rocchio & Crawford, 2015)	Polystichum munitum Acer circinatum Tsuga heterophylla Thuja plicata Pseudotsuga menziesii Acer macrophyllum Alnus rubra Oxalis oregana Rubus spectabilis Oplopanax horridus	Alnus rubra Geum macrophyllum Polystichum munitum Pteridium aquilinum Urtica dioica	Arnica lanceolata Carex hendersonii Corallorhiza maculata Listera cordata Listera caurina Viola sempervirens	Digitalis purpurea Hedera helix Geranium robertianum Ranunculus repens
North Pacific Mesic Western Hemlock-Silver Fir Forest (Henderson et al., 1989, 1992; Crawford et al., 2009; Rocchio & Crawford, 2015)	Tsuga heterophylla Abies amabilis Chamaecyparis nootkatensis Vaccinium ovalifolium Oxalis oregana Blechnum spicant Rubus pedatus	Alnus rubra Geum macrophyllum Polystichum munitum Pteridium aquilinum	Arnica lanceolata Corallorhiza maculata Corallorhiza mertensiana Elliottia pyroliflora Monotropa uniflora Orthilia secunda Polystichum andersonii Rubus pedatus Streptopus lanceolatus Streptopus streptopoides Viola sempervirens	Geranium robertianum
North Pacific Montane Massive Bedrock, Cliff and Talus	Chamaecyparis nootkatensis Tsuga spp. Thuja plicata Pseudotsuga menziesii	-	Aspidotis densa Asplenium viride Cryptogramma acrostichoides Luina hypoleuca	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
(Rocchio & Crawford, 2015)	Abies spp. Acer circinatum Alnus spp. Ribes spp.		Penstemon davidsonii var. davidsonii Penstemon rupicola Polypodium hesperium Polystichum andersonii Sedum oreganum Selaginella wallacei	
North Pacific Montane Shrubland (Henderson et al., 1989, 1992; Crowe & Clausnitzer, 1997; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Acer circinatum Vaccinium membranaceum Ceanothus velutinus Holodiscus discolor Philadelphus lewisii Xerophyllum tenax Rubus parviflorus	Rubus parviflorus (ground disturbance)	-	-
North Pacific Mountain Hemlock Forest (Henderson et al., 1989, 1992; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Tsuga mertensiana Abies amabilis Elliottia pyroliflorus, Rubus lasiococcus Clintonia uniflora Orthilia secunda Streptopus lanceolatus var. curvipes (= S. roseus) Valeriana sitchensis Tiarella trifoliata var. unifoliata Luzula glabrata Rubus pedatus Rhododendron albiflorum Menziesia ferruginea Vaccinium membranaceum Vaccinium ovalifolium	-	Clintonia uniflora Menziesia ferruginea Pectiantia breweri (= Mitella breweri) Pectiantia pentandra (= Mitella pentandra) Rhododendron albiflorum Rubus pedatus Streptopus lanceolatus	-
North Pacific Oak Woodland (Erickson, 1978; Johnson, 1988; Tannas, 2001; Chappell, 2006a; Wilson et al., 2008; Rocchio &	Quercus garryana Pseudotsuga menziesii Arbutus menziesii Symphoricarpos albus Holodiscus discolor Rosa spp. Mahonia aquifolium (=Berberis	Amsinckia menziesii Bromus carinatus Camassia quamash Carex tumulicola (grazing) Elymus glaucus Fragaria vesca (grazing, soil disturbance)	Dichelostemma congestum Festuca roemeri Fritillaria affinis Piperia elegans Trillium parviflorum Trillium ovatum	Cytisus scoparius Arrhenatherum elatius Avena fatua Dactylis glomerata Holcus lanatus Poa pratensis Prunus avium

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Crawford, 2013, 2015; D. Wilderman, pers. comm., April 10, 2017)	aquifolium) Amelanchier alnifolia Oemleria cerasiformis Festuca roemeri Carex inops ssp. inops Bromus carinatus Danthonia californica Elymus glaucus Camassia quamash Vicia americana Galium aparine Fragaria vesca Lomatium utriculatum Lithophragma parviflora Synthris reneformis Balsamorhiza deltoidea Sanicula crassicaulis Erythronium oregonum Potentilla glandulosa Delphinium trollifolium Cardamine nuttallii	Galium aparine Mahonia aquifolium (=Berberis aquifolium) Oemleria cerasiformis Symphoricarpos albus Carex inops ssp. inops Camassia quamash		Crataegus monogyna Agrostis capillaris Anthoxanthum odoratum Phleum pratense Bromus diandrus (= B. rigidus) Bromus hordeaceus Cirsium arvense Plantago lanceolata Rumex acetosella Cynosurus echinatus Festuca arundinacea Geranium robertianum Hypericum perforatum
North Pacific Serpentine Barren (Kruckeberg, 1992; Freeman & Reveal, 2005; Rocchio & Crawford, 2013, 2015)	Pseudotsuga menziesii Pinus ponderosa Pinus monticola Aspidotis densa Arctostaphylos nevadensis Pseudoroegneria spicata Pinus contorta var. latifolia Pinus albicaulis Abies lasiocarpa Tsuga mertensiana Juniperus communis Ledum glandulosum Vaccinium scoparium Festuca viridula Poa curtifolia Aconogonon davisiae	-	Aspidotis densa Festuca viridula Polystichum imbricans ssp. imbricans Polystichum kruckebergii Polystichum lemmonii Polystichum scopulinum	-
North Pacific Wooded Volcanic Flowage	Pseudotsuga menziesii Pinus contorta	-	-	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
(Crawford et al., 2009; Rocchio & Crawford, 2015)	Pinus monticola Abies lasiocarpa Acer circinatum Vaccinium membranaceum Arctostaphylos uva-ursi Mahonia nervosa Amelanchier alnifolia Xerophyllum tenax			
Northern Rocky Mountain Avalanche Chute Shrubland (Daubenmire & Daubenmire, 1968; Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	Abies lasiocarpa Acer glabrum Alnus viridis ssp. sinuata Alnus incana Populus balsamifera ssp. trichocarpa Populus tremuloides Cornus sericea Paxistima myrsinites Prunus emarginata Salix scouleriana Sorbus scopulina Sorbus sitchensis	n/a	Clintonia uniflora	-
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998; Lillybridge et al., 1995; Crowe & Clausnitzer, 1997; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Pseudotsuga menziesii Pinus ponderosa Pinus contorta var. latifolia Pinus monticola Larix occidentalis Calamagrostis rubescens Carex geyeri Pseudoroegneria spicata Carex rossii Arctostaphylos uva-ursi Acer glabrum Juniperus communis Physocarpus malvaceus Purshia tridentata Symphoricarpos albus Spiraea betulifolia Vaccinium membranaceum	Arnica cordifolia (grazing) Balsamorhiza sagittata (grazing) Carex concinnoides (logging, soil disturbance) Carex rossii (grazing, soil disturbance) Danthonia unispicata (grazing) Eriogonum heracleoides (grazing) Luina hypoleuca (grazing) Lupinus (caudatus, laxiflorus) (grazing) Symphoricarpos albus Poa secunda Potentilla gracilis (grazing) Pteridium aquilinum Thalictrum occidentale (soil disturbance) Trifolium longipes (trampling)	Agrostis variabilis Calochortus elegans var. elegans Carex (cordillerana, backii) (grazing) Erigeron speciosus	Linaria dalmatica Poa compressa Poa pratensis

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Northern Rocky Mountain Foothill Conifer Wooded Steppe (Daubenmire & Daubenmire, 1968; Lillybridge et al., 1995; Johnson, 1998; Rocchio & Crawford, 2013, 2015)	Pinus ponderosa Pseudotsuga menziesii Pseudoroegneria spicata Poa secunda Hesperostipa spp. Achnatherum spp. Elymus elymoides (= Sitanion hystrix) Festuca idahoensis Festuca campestris	Achillea millefolium Antennaria luzuloides (grazing) Artemisia tridenta ssp. wyomingensis (grazing, lack of fire) Balsamorhiza sagittata (grazing) Elymus elymoides (= Sitanion hystrix) Eriogonum heracleoides (grazing) Koeleria macrantha Lomatium nudicaule	Agoseris retrorsa Festuca campestris Frasera albicaulis Orobanche fasciculata Poa cusickii ssp. cusickii Trifolium macrocephalum	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Centaurea spp.
Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland (Daubenmire, 1970; Tisdale, 1986; Crowe & Clausnitzer, 1997; Johnson, 1998, 2004; Tannas, 2001; Johnson & Swanson, 2005; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Pseudoroegneria spicata Festuca campestris Festuca idahoensis Hesperostipa comata Achnatherum hymenoides Achnatherum (nelsonii, occidentale) Achnatherum richardsonii Hesperostipa curtiseta Koeleria macrantha Leymus cinereus Elymus trachycaulus Bromus inermis ssp. pumpellianus (= B. pumpellianus) Pascopyrum smithii Carex filifolia Danthonia intermedia	Agoseris glauca (grazing, erosion) Amsinckia menziesii Aristida purpurea var. longiseta Artemisia frigida (grazing) Balsamorhiza (sagittata, serrata, incana) Elymus elymoides (= Sitanion hystrix) Eriogonum heracleoides (grazing) Gaillardia aristata (grazing) Gallium boreale (grazing) Geranium viscosissimum (grazing) Hieracium scouleri Leymus cinereus Lomatium nudicaule Madia glomerata (grazing) Penstemon deustus (grazing) Penstemon venustus (grazing) Perideridia gairdneri (grazing) Potentilla gracilis (grazing)	Carex petasata (grazing) Carex vallicola (grazing) Festuca campestris Frasera albicaulis Orobanche fasciculata	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Ventenata dubia Bromus inermis Phleum pratense Poa pratensis Hypericum perfoliatum Potentilla recta Euphorbia virgata Centaurea spp.
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998;	Abies grandis Tsuga heterophylla Thuja plicata Picea engelmannii Pseudotsuga menziesii Asarum caudatum Clintonia uniflora Coptis occidentalis	Arnica cordifolia (grazing) Astragalus canadensis var. mortonii Carex concinnoides (logging, soil disturbance) Carex rossii (grazing, soil disturbance) Lathyrus pauciflorus (grazing)	Actaea rubra Aralia nudicaulis Arnica parryi ssp. parryi Asarum caudatum Calypso bulbosa Carex bolanderi Clintonia uniflora Corallorhiza maculata	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Lillybridge et al., 1995; Crowe & Clausnitzer, 1997; Rocchio & Crawford, 2013, 2015)	Prosartes hookeri Gymnocarpium dryopteris Tiarella trifoliata Trientalis borealis ssp. latifolia Trillium ovatum Viola glabella	Lupinus (caudatus, laxiflorus) (grazing) Potentilla gracilis (grazing) Spiraea betulifolia (grazing, logging, soil disturbance) Thermopsis montana var. ovata (grazing) Trifolium longipes (trampling) Linnaea borealis (logging) Pteridium aquilinum Urtica dioica	Pectiantia breweri (= Mitella breweri) Pectiantia pentandra (= Mitella pentandra)	
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (Daubenmire & Daubenmire, 1968; Johnson, 1998; Rocchio & Crawford, 2013, 2015)	Physocarpus malvaceus Spiraea douglasii Amelanchier alnifolia Prunus emarginata Prunus virginiana Holodiscus discolor Symphoricarpos albus Menziesia ferruginea Crataegus douglasii Rosa spp.	Agastache urticifolia (grazing) Crataegus douglasii (grazing, lack of fire) Eriogonum heracleoides (grazing) Potentilla gracilis (grazing)	Menziesia ferruginea	Poa pratensis Phleum pratense Centaurea solstitialis Hypericum perfoliatum Poa pratensis Prunus cerasifera
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998, 2004; Lillybridge et al., 1995; Crowe & Clausnitzer, 1997; Tannas, 2001; LANDFIRE, 2007; Rocchio & Crawford, 2013, 2015)	Pinus ponderosa Pseudoroegneria spicata Hesperostipa spp. Achnatherum spp. Festuca idahoensis Festuca campestris Calamagrostis rubescens Carex geyeri Artemisia tridentata Arctostaphylos uva-ursi Arctostaphylos patula Ceanothus velutinus Physocarpus malvaceus Purshia tridentata Symphoricarpos albus Prunus virginiana Amelanchier alnifolia Rosa spp.	Achnatherum (nelsonii, occidentale) (grazing) Arnica cordifolia (grazing) Artemisia tridentata? Balsamorhiza sagittata (grazing) Ericameria nauseosa (grazing) Eriogonum heracleoides (grazing) Gaillardia aristata (grazing) Lupinus (caudatus, laxiflorus) (grazing) Hieracium scouleri Madia glomerata (grazing) Potentilla gracilis (grazing) Prunus virginiana Senecio integerrimus var. exaltatus (grazing) Symphoricarpos albus	Agoseris retrorsa Calochortus elegans var. elegans Festuca campestris Gaultheria ovatifolia Poa cusickii ssp. cusickii Pyrola picta Trifolium macrocephalum	Bromus (briziformis, commutatus, japonicus, hordeaceus, tectorum) Centaurea spp.

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Northern Rocky Mountain Subalpine Deciduous Shrubland (Crowe & Clausnitzer, 1997; Johnson, 1998, 2004, Rocchio & Crawford, 2013, 2015)	Menziesia ferruginea Rhamnus alnifolia Ribes lacustre Rubus parviflorus Alnus viridis Rhododendron albiflorum Sorbus scopulina Sorbus sitchensis Vaccinium myrtillus Vaccinium scoparium Vaccinium membranaceum Shepherdia canadensis Ceanothus velutinus	Rubus parviflorus (ground disturbance)	Menziesia ferruginea Rhododendron albiflorum	-
Northern Rocky Mountain Subalpine Woodland and Parkland (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998, 2004, Rocchio & Crawford, 2013, 2015)	Pinus albicaulis Larix lyallii Abies lasiocarpa Phyllodoce glanduliflora Phyllodoce empetriformis Empetrum nigrum Cassiope mertensiana Festuca viridula Vahlodea atropurpurea Luzula glabrata Juncus parryi	Achnatherum (nelsonii, occidentale) (grazing) Anaphalis margaritacea Arnica cordifolia (grazing) Carex rossii (grazing, soil disturbance) Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling) Hieracium albiflorum Leptosiphon nuttallii ssp. nuttallii (grazing) Lupinus spp. Penstemon venustus (grazing) Juncus parryi Achillea millifolium Thalictrum occidentale (soil disturbance)	Arnica parryi ssp. parryi Empetrum nigrum (trampling) Eucephalus ledophyllus var. ledophyllus Festuca viridula Phyllodoce empetriformis (trampling) Phyllodoce glanduliflora (trampling) Packera streptanthifolia Sorbus sitchensis var. sitchensis Vahlodea atropurpurea	-
Northern Rocky Mountain Subalpine-Upper Montane Grassland (Johnson, 1988, 1998, 2004; Crowe & Clausnitzer, 1997; Tannas, 2001; Johnson &	Koeleria macrantha Festuca campestris Festuca idahoensis Festuca viridula Achnatherum (nelsonii, occidentale) Achnatherum richardsonii Bromus inermis ssp. pumpellianus Elymus trachycaulus	Agoseris glauca (grazing, erosion) Danthonia intermedia (grazing) Juncus parryi Achillea millifolium Achnatherum (nelsonii, occidentale) (grazing) Antennaria lanata Bromus carinatus	Agoseris aurantiaca var. aurantiaca Anemone occidentalis Arnica mollis Eriogonum pyrolifolium Festuca campestris Carex hoodii (grazing) Carex scirpoidea var. pseudoscirpoidea	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Swanson, 2005; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Phleum alpinum Trisetum spicatum Carex hoodii Carex obtusata Carex scirpoidea Lupinus argenteus var. laxiflorus Potentilla diversifolia Potentilla flabellifolia Fragaria virginiana Chamerion angustifolium	Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling) Leptosiphon nuttallii ssp. nuttallii (grazing) Lupinus sericeus (grazing) Penstemon spp. Potentilla gracilis (grazing) Carex pachystachya Chamerion angustifolium Collinsia parviflora Fragaria virginiana (grazing, soil disturbance) Hieracium scouleri Potentilla gracilis	Podagrostis humilis (= Agrostis humilis) Rainiera stricta Trisetum spicatum (grazing)	
Northern Rocky Mountain Western Larch Savanna (Johnson, 1988, 1998; Crowe & Clausnitzer, 1997; Rocchio & Crawford, 2013, 2015)	Larix occidentalis Pseudotsuga menziesii Pinus contorta var. latifolia Arctostaphylos uva-ursi Calamagrostis rubescens, Linnaea borealis Spiraea betulifolia Vaccinium caespitosum Xerophyllum tenax Ligusticum grayi Carex geyeri	Achnatherum (nelsonii, occidentale) (grazing) Carex concinnoides (logging, soil disturbance) Madia glomerata (grazing) Potentilla gracilis (grazing) Senecio integerrimus var. exaltatus (grazing)	Ligusticum grayi	-
Rocky Mountain Alpine Bedrock and Scree (Crawford et al., 2009; Rocchio & Crawford, 2013, 2015)	n/a	n/a	Agrostis variabilis Aspidotis densa Asplenium viride Athyrium distentifolium (= A. americanum) Boechera lemmonii Elmera racemosa Oxyria digyna Penstemon davidsonii var. davidsonii Penstemon rupicola Silene acaulis	n/a

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Rocky Mountain Alpine Dwarf-Shrubland, Fell-Field, and Turf (Johnson, 1998, 2004, Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Cassiope mertensiana Salix arctica Salix reticulata Salix vestita Phyllodoce empetriformis Erigeron spp. Luetkea pectinata Antennaria lanata Oreostemma alpigenum (= Aster alpigenus) Pedicularis spp. Castilleja spp. Deschampsia caespitosa Caltha leptosepala ssp. howellii Erythronium spp. Juncus parryi Luzula piperi Carex spectabilis Carex nigricans Polygonum bistortoides Arenaria capillaris Geum rossii Kobresia myosuroides Minuartia obtusiloba Myosotis asiatica Paronychia pulvinata Phlox pulvinata Sibbaldia procumbens Silene acaulis Trifolium dasyphyllum Trifolium parryi Artemisia arctica Carex elynoides Carex siccata Carex scirpoidea Carex nardina Carex rupestris Festuca brachyphylla Festuca idahoensis	Erigeron compositus Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling)	Antennaria alpina Boechera lemmonii Caltha leptosepala ssp. howellii Carex proposita (recreation, trampling) Carex raynoldsii (grazing) Carex scirpoidea var. pseudoscirpoidea Luzula piperi Minuartia obtusiloba Phyllodoce empetriformis (trampling) Salix arctica Salix nivalis Sibbaldia procumbens Silene acaulis Cassiope tetragona var. saximontana Trisetum spicatum (grazing) Veronica cusickii	-

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Rocky Mountain Aspen Forest and Woodland (Johnson, 1988, 1998, 2004; Crowe & Clausnitzer, 1997; Tannas, 2001; Hadfield & Magelssen, 2004; Rocchio & Crawford, 2013, 2015; Wilson et al., 2014)	Populus tremuloides Symphoricarpos oreophilus Symphoricarpos albus	Agastache urticifolia (grazing) Bromus carinatus (grazing, soil disturbance) Elymus glaucus Potentilla gracilis (grazing) Symphoricarpos albus Veratrum californicum	Carex vallicola (grazing)	Poa pratensis Cirsium spp.
Rocky Mountain Cliff, Canyon and Massive Bedrock (Rocchio & Crawford, 2013, 2015)	Pseudotsuga menziesii Pinus ponderosa Populus tremuloides Abies lasiocarpa Juniperus occidentalis Amelanchier alnifolia Juniperus communis Holodiscus sp. Ribes sp. Penstemon sp. Physocarpus sp. Rosa sp. Mahonia sp.	-	Cryptogramma acrostichoides Lewisia columbiana Penstemon davidsonii var. davidsonii Penstemon rupicola Polypodium hesperium	-
Rocky Mountain Lodgepole Pine Forest (Rocchio & Crawford, 2013, 2015)	Pinus contorta var. latifolia Acer glabrum Amelanchier alnifolia Holodiscus discolor Salix scouleriana Rosa gymnocarpa Shepherdia canadensis Spiraea betulifolia Symphoricarpos albus Vaccinium membranaceum Mahonia repens Ceanothus velutinus Paxistima myrsinites Arctostaphylos uva-ursi A. nevadensis Vaccinium scoparium	Elymus elymoides (= Sitanion hystrix) Salix scouleriana Symphoricarpos albus	Agrostis variabilis Anemone drummondii	Poa pratensis

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Xerophyllum tenax Calamagrostis rubescens Carex geyeri			
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998, 2004; Lillybridge et al., 1995; Rocchio & Crawford, 2013, 2015)	Picea engelmannii Abies lasiocarpa Pseudotsuga menziesii Pinus contorta var. latifolia Larix occidentalis Paxistima myrsinites Vaccinium scoparium Juniperus communis Calamagrostis rubescens Carex geyeri	Arnica cordifolia (grazing) Carex hoodii (logging) Carex rossii (grazing, soil disturbance) Linnaea borealis (logging) Pteridium aquilinum Sibbaldia procumbens (trampling) Thalictrum occidentale (soil disturbance) Thermopsis montana var. ovata (grazing)	Podagrostis humilis (= Agrostis humilis) Trisetum spicatum (grazing)	-
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland (Daubenmire & Daubenmire, 1968; Johnson, 1988, 1998, 2004, Rocchio & Crawford, 2013, 2015)	Picea engelmannii Abies lasiocarpa Pinus contorta var. latifolia Menziesia ferruginea Rhododendron albiflorum Actaea rubra Maianthemum stellatum Clintonia uniflora Cornus canadensis Erigeron eximius Gymnocarpium dryopteris Rubus pedatus Saxifraga bronchialis Tiarella spp. Lupinus latifolius ssp. subalpinus Valeriana sitchensis Luzula glabrata var. hitchcockii Calamagrostis Canadensis Xerophyllum tenax	Arnica cordifolia (grazing) Geum macrophyllum Lupinus latifolius ssp. subalpinus Pteridium aquilinum Senecio triangularis (grazing) Sibbaldia procumbens (trampling) Thalictrum occidentale (soil disturbance) Urtica dioica Veratrum californicum	Menziesia ferruginea Saxifraga bronchialis Packera streptanthifolia Rubus pedatus	-
Rocky Mountain Subalpine-Montane Mesic Meadow (Johnson, 1988, 1998, 2004, Rocchio &	Senecio triangularis Erigeron peregrinus Erythronium grandiflorum Ligusticum spp. Veratrum viride Valeriana spp.	Bromus carinatus (grazing, soil disturbance) Camassia quamash Chamerion angustifolium Danthonia intermedia (grazing)	Allium crenulatum Agoseris aurantiaca var. aurantiaca Annemone occidentalis Arnica mollis	Poa pratensis Bromus inermis Phleum pratense Hieracium caespitosum Hieracium aurantiacum

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
Crawford, 2013, 2015; Wilson et al., 2014)	Arnica chamissonis Camassia quamash Erigeron speciosus Eucephalus spp. Symphyotrichum spp. Mertensia spp. Chamerion angustifolium Penstemon procerus Geum macrophyllum Campanula rotundifolia Solidago canadensis Zigadenus elegans Thalictrum occidentale Senecio hydrophiloides Senecio serra Deschampsia caespitosa Koeleria macrantha Carex spp.	Erigeron glacialis var. glacialis (= E. peregrinus) (grazing, trampling) Fragaria virginiana (grazing, soil disturbance) Lupinus sericeus (grazing) Geum macrophyllum Potentilla gracilis Senecio serra Sibbaldia procumbens (trampling) Solidago canadensis Thermopsis montana var. ovata (grazing) Veratrum californicum	Arnica parryi ssp. parryi Boechera lemmonii Carex raynoldsii (grazing) Erigeron speciosus Eucephalus ledophyllus var. ledophyllus Packera streptanthifolia Penstemon procerus Rainiera strictaTrisetum spicatum (grazing) Vahlodea atropurpurea Zigadenus elegans	Ranunculus acris Leucanthemum vulgare
Willamette Valley Upland Prairie and Savanna (Johnson, 1988; Crowe & Clausnitzer, 1997; Tannas, 2001; Wilson et al., 2008; Alverson, 2009; Rocchio & Crawford, 2013, 2015; D. Wilderman, pers. comm., April 10, 2017)	Festuca roemeri Danthonia californica Carex inops ssp. inops Brodiaea coronaria ssp. coronaria Camassia quamash ssp. (azurea, maxima) Campanula rotundifolia Balsamorhiza deltoidea Cerastium arvense Dodecatheon hendersonii, Erigeron speciosus Hieracium scouleri Solidago simplex Solidago missouriensis Eriophyllum lanatum var. leucophyllus Fritillaria affinis var. affinis Lomatium utriculatum Lomatium triternatum (= L. pugetensis) Lotus micranthus	Achillea millefolium Amsinckia menziesii Carex tumulicola (grazing) Cerastium arvense (grazing) Fragaria virginiana (grazing, soil disturbance) Prunella vulgaris ssp. lanceolata (grazing) Viola adunca (grazing) Carex inops ssp. Inops (grazing, fire) Camassia quamash Lupinus albicaulis Lupinus lepidus	Festuca roemeri Delphinium nuttallii Sericocarpus rigidus Zigadenus venenosus var. venenosus Micranthes integrifolia Dodecatheon hendersonii Fritillaria affinis Hieracium scouleri	Cytisus scoparium Crataegus monogyna Avena fatua Hypericum perforatum Hypochaeris radicata Holcus lanatus Chrysanthemum leucanthemum Agrostis capillaris Anthoxanthum odoratum Poa pratensis Arrhenatherum elatius Hieracium pilosella Potentilla recta Centaurea spp. Schedonorus phoenix Trifolium subterraneum Vulpia myuros Rumex acetosella Plantago lanceolata

Ecological System	Diagnostics	Example Increasers	Example Decreasers	Example Invasive Plants
	Microseris laciniata Prunella vulgaris ssp. lanceolata Ranunculus occidentalis var. occidentalis Sericocarpus rigidus Viola adunca Zigadenus venenosus var. venenosus Symphoricarpos albus Rosa nutkana Toxicodendron diversilobum Amelanchier alnifolia Arctostaphylos uva-ursi			